UNIVERSITY OF TORONTO
3 1761 00016391 5

Digitized by the Internet Archive
in 2017 with funding from
University of Toronto

https://archive.org/details/alcoholdrugstraf00inte

Alcohol, Drugs, and Traffic Safety

Alcohol, Drugs, and Traffic Safety

PROCEEDINGS OF THE SIXTH INTERNATIONAL
CONFERENCE ON ALCOHOL, DRUGS, AND TRAFFIC SAFETY
TORONTO, SEPTEMBER 8-13, 1974

Edited by S. Israelstam and S. Lambert

ADDICTION RESEARCH FOUNDATION OF ONTARIO
Toronto, Canada

This conference was held in association with the International Committee on Alcohol, Drugs, and Traffic Safety and the International Council on Alcohol and Addictions.

HE
5614
I55
1974

LIBRARY
JUL
6
1976
OF TORONTO

International Standard Book Number: 0-88868-011-2
© 1975 by the Alcoholism and Drug Addiction Research Foundation of Ontario. All rights reserved. No part of this book may be reproduced in any form, except for brief quotation in a review or professional work, without permission in writing from the publisher, Marketing Services, 33 Russell Street, Toronto, Ontario M5S 2S1.

1975

Printed in Canada – House of Lind

Members of International Committee On Alcohol, Drugs, and Traffic Safety

Chairman: R. F. Borkenstein, U.S.A.

Rune Andreasson, Sweden
David Archibald, Canada
M. Benjamin, France
J.H.W. Birrell, Australia
Kjell Bjerver, Sweden
Roger Bonnichsen, Sweden
Mathatias Bussinger, Brazil
G. C. Drew, England
Kurt Dubowski, U.S.A.
Bernard H. Fox, U.S.A.
W. Froentjes, Netherlands
J. Gerchow, West Germany
L. Goldberg, Sweden
J.D.J. Havard, England
Ulrich Heifer, West Germany
Werner Janssen, West Germany
P. V. Joliet, U.S.A.
Paul Kielholz, Switzerland
Edeltraud Klebel, Austria
Hans Klette, Sweden
Minoru Kobayashi, Japan
J. L'Hoste, France
Douglas M. Lucas, Canada
Gottfried Machata, Austria
Jorge Mardones, Chile
J. Milcinski, Yugoslavia
Norman McCallum, Australia
Wladyslaw Nasilowski, Poland
Gunnar Nelker, Sweden
Pieter C. Noordzij, Netherlands
A. Ponsold, West Germany
William Preston, Australia
Ann Robinson, England
Wolfgang Schmidt, Canada
W. Spann, West Germany
John I. Tonge, Australia
Archer Tongue, Switzerland
Milan Vamosi, Sweden
Robert B. Voas, U.S.A.
Edward Wayne, England
Werner Winkler, West Germany
L. Zanaldi, Italy

The Sixth International Conference on Alcohol, Drugs and Traffic Safety would like to recognize the contributions to the field by the late George H. W. Lucas, Ph.D. and Ward Smith, Ph.D. Dr. Lucas was General Chairman and Dr. Smith was Program Chairman for the Second International Conference on Alcohol and Road Traffic which was held in Toronto in 1953.

The organizers of the Conference would like to express their thanks to the Government of Canada, the Government of Ontario and the following organizations for their generous assistance:

Health & Welfare Canada
Ministry of Transport of Canada
Ministry of Health of Ontario
Ministry of Transportation & Communications of Ontario
Addiction Research Foundation of Ontario
Canada Safety Council
Canadian Federation of Alcohol and Drug Dependencies
Centre of Forensic Science
Insurance Bureau of Canada
Junior League
Office de la Prevention de l'Alcoolisme et des autre
Toxicomanies, Ministry of Social Affairs
Government of Quebec
Traffic Injury Research Foundation of Canada

Committee of Honor

Chairman: Hon. W. Earl Rowe, P.C.

Peter Bawden, M.P.
Hon. Sidney L. Buckwold
W. J. Bennett
Hon. Keith Davey
Ian D. Davidson
Air Vice-Marshal J. A. Easton
Gérard Filion
Hon. Hugh John Fleming, P.C.
Louis Hébert
Hon. H. D. Hicks
John F. Irwin
Dr. Guy E. Joron
Brig.-Gen. Bruce J. Legge
Paul H. Leman
Raymond Lavoie
Ian D. Mair
Peter B. Mason
John H. Moore
Gérard Plourde
Judge Walter T. Robb
Dr. H. Rocke Robertson
Lucien G. Rolland
R. C. Scrivener
Mrs. W. Ross Thatcher
Mrs. R. W. Wadds
Right Rev. F. H. Wilkinson

Planning Committee

Chairman: H. D. Archibald
Vice-Chairman: W.B.G. Reynolds

R. F. Borkenstein
A. Boudreau
J. Cranford
R. Draper
P. J. Farmer
M. Jack
H. S. Jamieson
D. Lucas
A. F. W. Peart
H. J. Schankula
W. Schmidt
S. C. Wilson

The Planning Committee of the Sixth International Conference on Alcohol, Drugs, and Traffic Safety is delighted with this opportunity to join hands with the International Committee for this very important event.

This is the second time Canada and specifically the City of Toronto has been fortunate enough to host this conference, and we look forward to maintaining our excellent relationship with the International Committee on Alcohol, Drugs, and Traffic Safety.

I would like to take this opportunity to offer my personal thanks to my colleagues on the Planning Committee for their dedication to the objectives of the conference.

On behalf of the organizers of the conference, I also wish to extend my gratitude to the Committee of Honor, and the many individuals and organizations whose assistance ensured the success of this event.

H. D. Archibald,
Chairman,
Planning Committee

Program Committee

Chairman: WOLFGANG SCHMIDT, Toronto, Ontario, Canada

Section 1: CARL M. STROH, St. John's, Newfoundland, Canada
WOLFGANG SCHMIDT, Toronto, Ontario, Canada
ROBERT VOAS, Washington D.C., U.S.A.
JULIAN WALLER, Burlington, Vermont, U.S.A.

Section 2: HAROLD KALANT, Toronto, Ontario, Canada
J. ANTHONY CARPENTER, New Brunswick, New Jersey, U.S.A.
HERBERT MOSKOWITZ, Los Angeles, California, U.S.A.
HENRIK WALLGREN, Helsinki, Finland

Section 3: DOUGLAS M. LUCAS, Toronto, Ontario, Canada
KURT M. DUBOWSKI, Oklahoma City, Oklahoma, U.S.A.
GOTTFRIED MACHATA, Vienna, Austria

Section 4: PHILIP J. FARMER, Ottawa, Ontario, Canada
ROBERT F. BORKENSTEIN, Bloomington, Indiana, U.S.A.
HANS KLETTE, Lund, Sweden
H. LAURENCE ROSS, Denver, Colorado, U.S.A.
REGINALD G. SMART, Toronto, Ontario, Canada

Section 5: W.B.G. REYNOLDS, Toronto, Ontario, Canada
JEAN L'HOSTE, Arcueil, France
JAMES W. SWINEHART, Ann Arbor, Michigan, U.S.A.
G.J.S. WILDE, Kingston, Ontario, Canada

Contents

Foreword	vii
Program Committee	x
Table of Equivalents	xvi

I. The Epidemiology of Alcohol and Drug Related Traffic Accidents

J. A. Waller	Epidemiologic Issues About Alcohol, Other Drugs and Highway Safety	*3*
M. L. Selzer	Alcoholics and Social Drinkers: Characteristics and Differentiation	*13*
R. B. Voas	Roadside Surveys, Demographics and BACs of Drivers	*21*
P. C. Noordzij	Drinking and Driving in the Netherlands over a Four-Year Period	*33*
A. C. Wolfe	Characteristics of Late-night, Weekend Drivers: Results of the U.S. National Roadside Breath-testing Survey and Several Local Surveys	*41*
B. H. Fox *R. F. Borkenstein*	Patterns of Blood Alcohol Concentrations Among Drivers	*51*
B. M. Kapur	Patterns of Drug Abuse and Their Relationship to Traffic Accidents	*69*
B. E. Sabey *P. J. Codling*	Alcohol and Road Accidents in Great Britain	*73*
S. Kaye	Alcohol, Drugs and Carbon Monoxide in Traffic Fatalities in Puerto Rico	*85*
R. S. Sterling-Smith	Alcohol, Marijuana and Other Drug Patterns Among Operators Involved in Fatal Motor Vehicle Accidents	*93*
M. W. Perrine	Alcohol, Drugs, and Driving: Relative Priorities for Basic and Applied Research	*107*
G. W. May *W. E. Baker*	Human and Environmental Factors in Alcohol-Related Traffic Accidents	*129*
E. J. Woodhouse	The Prevalence of Drugs in Fatally Injured Drivers	*147*
O. Irgens-Jensen	The Relationship Between Self-Reported Drunken Driving, Alcohol Consumption, and Personality Variables Among Norwegian Students	*159*
E. W. Fine *P. Scoles* *M. J. Mulligan*	Alcohol Abuse in First Offenders Arrested for Driving While Intoxicated	*169*
I. Sandler *S. Palmer* *M. Holman* *R. Wynkoop*	Drinking Characteristics of DWI Individuals Screened as Problem Drinkers	*175*
P. F. Zelhart, Jr. *B. C. Schurr* *P. A. Brown*	The Drinking Driver: Identification of High-Risk Alcoholics	*181*
M. W. Perrine	The Vermont Driver Profile: A Psychometric Approach to Early Identification of Potential High-Risk Drinking Drivers	*199*
R. Zylman	Mass Arrests for Impaired Driving May Not Prevent Traffic Deaths	*225*
A. Kornaczewski	Identification of the Drinking Driver	*239*
J. S. Tamerin	The Importance of Psychosocial Factors on Drinking in Alcoholics: Relevance for Traffic Safety	*249*

II. Pharmacological, Physiological, and Psychological Aspects Relevant to Driving Impairment

M. Frankenhaeuser	Drug Effects on Emotions: Relevance to Driving Accidents	*259*
E. M. Sellers	The Pharmacokinetic Component of Drug Effects on Driving Skills	*271*
H. Moskowitz	Validity of Driving Simulator Studies for Predicting Drug Effects in Real Driving Situations	*295*
J. Levett *L. Karras* *G. Hoeft*	Effects of Alcohol on Visual Accomodation and Eye Movement Latency	*305*
M. Kobayashi	Effects of Small Doses of Alcohol on the Eye Movements of Drivers	*313*
J. C. Aschoff *W. Becker* *D. Weinert*	Computer-Electronystagmography – a Useful Tool in Evaluating Influence of Psychopharmacological Drugs on Traffic Safety	*319*
R. G. Mortimer *S. P. Sturgis*	Effects of Low and Moderate Levels of Alcohol on Steering Performance	*329*
R. R. Thompson *J. A. Tennant* *B. S. Repa*	Vehicle-Borne Drunk Driver Countermeasures	*347*
P. Dussault *C. I. Chappel*	Difference in Blood Alcohol Levels Following Consumption of Whisky and Beer in Man	*365*
H. Kalant *A. E. LeBlanc* *A. Wilson* *S. Homatidis*	Sensorimotor and Physiological Effects of Various Alcoholic Beverages	*371*
J. N. Santamaria	Social Patterns of Drinking in Young People and the Related Blood Alcohol Levels	*381*
A. Solarz	Medical Conclusions from the Clinical Tests of Drunken Drivers with High Alcohol Levels	*389*
P. Kielholz	Alcohol, Drugs, and Driving Behaviour in Switzerland	*395*
H. Moskowitz *J. Murray*	The Effect of Alcohol on Human Information Processing Rate	*399*
P. Verhaegen *E. van Keer* *R. Gambart*	The Influence of Small Doses of Alcohol on the Rate of Decision Making	*405*
A. B. Clayton *T. A. Betts* *P. G. Harvey*	The Influence of Sex and Personality Factors upon the Effects of Tranquillizers on Driving Performance	*415*
R. Burford *I. W. French* *A. E. LeBlanc*	The Combined Effects of Alcohol and Common Psychoactive Drugs: I. Studies on Human Pursuit Tracking Capability	*423*
A. Smiley *A. E. LeBlanc* *I. W. French* *R. Burford*	The Combined Effects of Alcohol and Common Psychoactive Drugs: II. Field Studies with an Instrumented Automobile	*433*
O. Bø *J.F.W. Haffner* *Ø. Langard* *J. H. Trumpy* *J. E. Bredesen* *P. K. M. Lunde*	Ethanol and Diazepam as Causatiave Agents in Road Traffic Accidents	*439*

A. E. LeBlanc *A. Wilson*	Drug After Effects and Traffic Safety	*449*
B. B. Coldwell *B. H. Thomas* *K. Bailey*	Interactions of Some Street Drugs	*453*
H. M. Franks *G. A. Starmer* *G. B. Chesher* *D. M. Jackson* *V. R. Hensley* *W. J. Hensley*	The Interaction of Alcohol and Δ9-Tetrahydrocannabinol in man: Effects on Psychomotor Skills Related to Driving	*461*

III. Analytical Aspects

A. S. Curry	Reliability and Significance of Results of Alcohol and Drug Analyses	*469*
K. M. Dubowski	Recent Developments in Breath-Alcohol Analysis	*483*
R. Bonnichsen	Aspects of Drug Analyses in Relation to Road Traffic Legislation and Supervision	*495*
A. W. Jones *B. M. Wright* *T. P. Jones*	A Historical and Experimental Study of the Breath/Blood Alcohol Ratio	*509*
J. Levett *L. Karras*	Errors in Current Alcohol Breath Analysis	*527*
M. F. Mason *D. Hutson*	The Range of Concentrations of Free Acetone in the Plasma and Breath of Diabetics and Some Observations on its Plasma/Breath Ratio	*533*
G. Machata	The Advantages of Automated Blood Alcohol Determination by Head Space Analysis	*541*
M. H. Breen *K. F. Siler* *D. S. Pearce*	A Comparison between the Gas Chromatograph Intoximeter and a Direct Blood Analysis	*549*
P. C. Noordzij	Comparison of Blood and Breath Testing Under Field Conditions	*553*
L. S. Harris *C. N. Hodnett* *J. B. Mullen*	Breath Alcohol Analysis by Gas Chromatography: Two Years' Experience with Field Collected Samples	*561*
A. E. Robinson	Practical Scientific Problems Associated with Drinking and Driving Legislation in England	*573*
P. Zink *G. Reinhardt*	Alcohol Concentration in Urine and Its Forensic Evidence	*579*
R. N. Harger	The Hamburg, W. Germany, 1973 Report Questioning the Reliability of Breath Alcohol Instruments for Medicolegal Use in Traffic Cases	*583*
R. F. Turk *A. J. McBay* *P. Hudson* *M. M. Bullaboy*	Involvement of Alcohol, Carbon Monoxide and Other Drugs in Traffic Fatalities	*597*
B. S. Finkle	"Will the Real Drugged Driver Please Stand Up?" An Analytical Toxicology Assessment of Drugs and Driving	*607*
R. Forney, Jr. *I. Sunshine*	Immunoassays for the Detection of Drugs in Drivers	*613*
W. E. VanNote *N. C. Jain*	A System for Breath Alcohol Analysis, and a System to Collect and Preserve Breath Evidence of Blood Intoxicants	*619*

L. C. Kier	A Simple Method for the Determination of the Smoking of Marijuana	*623*
B. M. Kapur *L. McLaughlin*	Quality Control in a Toxicology Laboratory	*627*

IV. Control and Prevention

J. D. J. Havard	Cross-National Comparisons of Drinking Driving Laws	*637*
R. F. Borkenstein	Problems of Enforcement, Adjudication and Sanctioning	*655*
H. L. Ross	The Effectiveness of Drinking-and-Driving Laws in Sweden and Great Britain	*663*
B. R. Carr *H. Goldberg* *C. M. L. Farbar*	The Canadian Breathalizer Legislation: An Inferential Evaluation	*679*
L. W. Chambers *R. S. Roberts* *C. C. Voelker*	The Epidemiology of Traffic Accidents and the Effect of the 1969 Breathalyser Law in Canada	*689*
J. Hoday	Law Enforcement Requirements for the Detection and Prevention of Drinking and Driving in Canada	*699*
J. K. McLellan	Enforcement of the Law in Great Britain Regarding Motorists Impaired by Drink: Success and Problems	*705*
R. T. Hawthorne	The Use of a Screening Test for Drinking Drivers in Conjunction with an Automatic Data Processing Unit	*709*
B. S. Hetzel *G. A. Ryan* *F. McDermott* *E. S. R. Hughes*	Compulsory Blood Alcohol Determinations in Road Crash Casualties: Experience Following Recent Australian Legislation	*717*
F. A. Seixas *A. L. Hopson*	The Effect of Rehabilitation on the Driving Behavior of Problem Drinkers	*723*
J. L. Malfetti *K. J. Simon*	A Comparison of Changes in Knowledge and Attitude Between Problem Drinkers and Non-Problem Drinkers Following a Reeducation Program	*737*
P. Brown *P. F. Zelhart* *B. C. Schurr*	Evaluating the Effectiveness of Reeducation Programs for Convicted Impaired Drivers	*749*
M. Blumenthal *H. L. Ross*	Judicial Discretion in Drinking-Driving Cases: An Empirical Study of Influences and Consequences	*755*
W. Schmidt *A. Kornaczewski*	The Effect of Lowering the Legal Drinking Age in Ontario on Alcohol-Related Motor Vehicle Accidents	*763*
P. C. Whitehead *J. Craig* *N. Langford,* *C. MacArthur* *B. Stanton*	The Impact of the Change in the Drinking Age on the Collision Behaviour of Young Drivers	*771*
J. H. W. Birrell	The Compulsory Breathalyzer .05% Legislation in Victoria	*775*

V. Public Education and Information

D. Fee	Drunk Driving: Outline of a Public Information and Education Program	*789*

J. W. Swinehart	Public Information Programs Related to Alcohol, Drugs, and Traffic Safety	*799*
G. J. S. Wilde	Evaluation of Effectiveness of Public Education and Information Programmes Related to Alcohol, Drugs, and Traffic Safety	*813*
D. W. Hossack	The Investigation of Blood Alcohol Levels in 967 Road Accident Fatalities	*825*
P. J. Farmer	The Edmonton Study: A Pilot Project to Demonstrate the Effectiveness of a Public Information Campaign on the Subject of Drinking and Driving	*831*
A. B. Saunders	Seven Years Experience of Blood-Alcohol Limits in Britain	*845*
R. J. Joling	Socio-Medico-Legal Aspects of Alcohol and Alcoholism	*855*
L. N. Hames	Can Alcohol Education Change the Role of Youth on Our Highways?	*861* ✓
J. Pierce *D. Hieatt* *M. Goodstadt* *L. Lonero* *A. Cunliffe* *H. Pang*	Experimental Evaluation of a Community-Based Campaign Against Drinking and Driving	*869*
P. Finn	The Role of Attitudes in Secondary School Alcohol-Traffic Safety Education	*881* ✓
J. L'Hoste	Présentation d'une Campagne sur l'Alcool et la Conduite Réalisée de Février à Mai 1974 en France	*889*
J. L. Nichols *R. E. Reis*	One Model for the Evaluation of ASAP Rehabilitation Efforts	*893*
Å. Lindgren	Motor Claims of Abstaining Drivers	*927*
	Author Index	*937*
	Acknowledgements	*939*

As these Proceedings are the outcome of an International Conference, authors have used a variety of notations and symbols. Thus both English and American spelling is used depending on the preference of each author. However, the use of the period has been standardized throughout to denote the decimal, and accordingly, the comma has been used to mark off thousands. Methods of expressing alcohol concentrations vary throughout the proceedings and therefore a table of equivalence is provided below.

METHODS OF EXPRESSING THE CONCENTRATION OF ALCOHOL IN THE TISSUES AND BODY FLUIDS[a]

Table of Equivalents

Milligrammes per 100 millilitres (mg/100 ml.) (mg %)	*Grammes per Litre Parts per Thousand (Promille) (°/oo)*	*Grammes per 100 millilitres (g/100 ml) %*
5	0.05	0.005
10	0.1	0.01
20	0.2	0.02
30	0.3	0.03
40	0.4	0.04
50	0.5	0.05
60	0.6	0.06
70	0.7	0.07
80	0.8	0.08
90	0.9	0.09
100	1.0	0.10
110	1.1	0.11
120	1.2	0.12
130	1.3	0.13
140	1.4	0.14
150	1.5	0.15
160	1.6	0.16
170	1.7	0.17
180	1.8	0.18
190	1.9	0.19
200	2.0	0.20
250	2.5	0.25
300	3.0	0.30
350	3.5	0.35
400	4.0	0.40

---

[a] As the specific gravity of body fluids and tissues is close to unity, the discrepancy between the two modes of expression is usually negligible.

Foreword

The first International Conference on Alcohol and Road Traffic was held in Stockholm, Sweden, in 1950. The intention of the organizers who represented several Swedish insurance companies, was to assemble a small group of interested people to study the problem. The "small group" became 135 participants from Europe and North America. During the conference, the International Committee on Alcohol, Drugs, and Traffic Safety was formed to pilot future conferences. A second conference was held in Toronto, Canada in 1953, a third in London, England in 1962, a fourth in Bloomington, Indiana, U.S.A. in 1965, and a fifth in Freiburg, Germany in 1969. Proceedings resulted from each of these conferences.

The International Committee on Alcohol, Drugs, and Traffic Safety was strengthened considerably beginning in 1961 when a secretariat was established within the British Medical Association. Members of the International Committee have participated in many conferences and meetings where alcohol, drugs, and traffic safety were issues. A close liaison has been established with the International Council on Alcohol and Addiction and the International Drivers Behavior Research Association.

The goals of the Committee are to sponsor an International Conference on Alcohol, Drugs, and Traffic Safety approximately every four years. The Committee receives and approves invitations. These conferences have alternated between Europe and North America, although this has been a custom rather than a requirement. They provide continuity in collecting and disseminating essential information as well as promoting research in the field. The Committee also has organized numerous working parties in connection with other organizations in the field of traffic and transportation safety.

R. F. Borkenstein, Chairman
International Committee on Alcohol,
Drugs, and Traffic Safety.

SECTION I

The Epidemiology of Alcohol and Drug Related Accidents

Program Committee	*Head:* CARL STROH
	WOLFGANG SCHMIDT
	ROBERT VOAS
	JULIAN WALLER

Epidemiologic Issues About Alcohol, Other Drugs and Highway Safety

Julian A. Waller[1]

One cannot help but feel a sense of frustration in any discussion about alcohol, other drugs, and highway safety. Although new psychoactive drugs are still being discovered both alcohol and other basic mind altering chemicals have been known and used since antiquity. In the case of alcohol, there is now wide and virtually unanimous agreement that ingestion does contribute substantially to highway crashes But there is still some argument regarding the circumstances and extent of the contribution, and considerable confusion about appropriate countermeasures. As far as other common drugs such as marihuana, barbiturates, tranquilizers, and opiates are concerned, there is no agreement as to whether a safety problem exists or what to do if it does.

It is not my intention to repeat the extensive and convincing data about alcohol. Nor will I attempt to catalogue pharmacologic effects of various other drugs or try to predict how these effects might relate to possible phenomena on the highway. That has been done in the past, and it is now time to move on to other considerations. Therefore, this paper will be concerned with identifying several epidemiologic principles and their applications, and with a specific discussion of some recent data about marihuana, one of the most common drugs in current use.

I feel that this approach is warranted for several reasons. First, we are not involved in studying this problem simply out of scientific curiosity, but rather for administrative ends. As long as there is a shortage of resources, either for research or for action, we have a responsibility to direct our attention, wherever possible, to those parts of the phenomenon that currently appear to create the greatest social problem, or to have the greatest likelihood of creating a major problem in the future. Therefore, some guidelines are needed to suggest how to set priorities in research and action.

Second, social phenomena are the result of many interacting forces and commonly vary over time and from one geographic or cultural area to another. An international meeting provides a good opportunity for discussion of these differences.

Third, while reviewing recent papers from the epidemiologic viewpoint, I have been disturbed by some of the methodologic errors that are apparent. These errors, however, are not being brought to the attention of the many people who are exposed only to the conclusions of the work, and who consequently may be left with erroneous information because they know nothing of the methodology.

---

[1] Professor and Chairman, Department of Epidemiology and Environmental Health, University of Vermont, Burlington, Vermont, U.S.A.

THE FREQUENCY QUANTITY MODEL

Let us examine first the question of setting priorities. It is my contention that all drugs are not equal in potential hazard; nor are all users of these drugs; nor all circumstances of use. Where should we look first?

I believe this question can be answered by means of a model of frequency and quantity of deviant behavior. In this case, deviant behavior is defined as behavior which has high risk of initiating social problems. Now it is important to note that, with very rare exceptions, a perfect correlation does not exist, either with physical or biologic phenomena, between the presence of a cause or causal set and the occurrence of an effect. However, the stronger the causal set the more likely it is that the effect will occur, and the greater it will be.

As applied to drugs and highway safety the frequency-quantity model of deviancy, therefore, states the following:

a) The more frequently a drug is used in the highway setting the more often it is likely to be a problem.

b) The more impairing the effect of the drug, either because of its inherent nature or because of the usual quantity consumed, the more likely there is to be a problem.

Therefore, a drug (for example, caffeine) that is used frequently but is not impairing unless used in great quantity, will not create a serious problem. Nor will one that is impairing but that is consumed relatively infrequently by many or relatively often but by few. Among the many potential problem drugs the only ones that will create a problem of large proportions are those that simultaneously have high prevalence of use and relatively high quantity of impairment under the circumstances of use.

How many drugs on the North American continent meet these criteria at this time? Clearly alcohol does, both because of its frequency of use and the severe impairment that is associated with excessive use.

As the use of marihuana and hashish has been on the increase among teenagers and young adults it may be asked if these drugs meet the criteria. They may meet the first, but since it is difficult to measure the level of impairment one cannot tell if they meet the second.

Tobacco might be another possibility. It is widely used; it is commonly used in conjunction with alcohol (18), it is known to be associated with some cardiovascular impairment (14), and the levels of carbon monoxide generated are known to create mild impairment of cerebration (4). A few years ago we examined carboxyhemoglobin concentrations (COHb) and blood alcohol concentrations (BAC) among drivers fatally injured in crashes (18). We also estimated COHb based on smoking history, and we recorded BAC among drivers not in crashes but who were interviewed at times and places where fatal crashes had occurred. Compared to persons with a BAC of <20 mg/100 ml and COHb <5%, those with COHb >5% were overrepresented about 3 times among the fatalities, and those with COHb >5% plus a BAC of <20 mg/100 ml overrepresented even more. Alcohol and COHb appeared to have an additive effect in this overrepresentation. These data appear in Table I. Because the methods of collection were not entirely comparable, however, the results are only preliminary. Also, we do not know whether this possible overrepresentation might apply to all crashes, or only to fatalities in which the reduced oxygen-carrying capacity of blood might adversely affect the ability to survive. However, others have found similar moderate overrepresentation of smokers in crashes of all degrees of severity, although the other studies have not controlled for the relationship between smoking and drinking behavior (1).

TABLE I *Blood alcohol concentration, carboxyhemoglobin and risk of fatal crash*

BAC (mg/100 ml)	COHb (%)	Relative Risk
<20	<5	1.0
	≥5	3.2
20-99	<5	1.8
	≥5	3.8
≥100	<5	40.7
	≥4	48.7

I do not believe that at this time there is any other drug in North America that meets both criteria, although for a brief time LSD appeared to be a possible candidate. In other cultures, additional drugs might be a problem.

One recent phenomenon in the United States exemplifies the model. In many states the legal age for alcohol consumption has recently been reduced from age 20 or 21 to age 18. Some have predicted that this would increase the prevalence of exposure and thus cause a rise in the crash problem. Others, including myself, have suggested that data show that exposure among persons age 18-20, albeit illegal, was already the rule rather than the exception, and, therefore, we did not predict a sudden surge of alcohol related deaths.

Data now available from several states show that there has been an increase in frequency of alcohol use among teenagers in those areas that had previously enforced alcohol limitation by age in rigorous fashion (7). According to one report (21) this increase can be converted into about three additional deaths annually per 100,000 persons age 15-20. In those geographic areas that previously had lax enforcement of drinking laws, however, such an increase has not occurred (7).

MEASURING THE OCCURRENCE AND EXTENT OF THE PROBLEM

Next, let us turn to some of the factors that may affect not only the occurrence of a problem in different cultures, geographic areas, and at different times, but also the perceptions of the extent of the problem. Any epidemiologic study must consider these and related factors if it is to be usefully applied in more than one setting.

The actual definition of a highway fatality is one such issue. How can we compare fatality rates between nations if in one country a person is not defined as a highway fatality unless he died at the crash site, in another all deaths within the first 24 hours are counted, in still others deaths in the first week are included, in several countries the criterion is death within 30 days, and in the United States those who die of their injuries after up to one year may be counted? I urge the establishment of a task force to develop appropriate correction figures and to update these periodically so that we can begin to have some way of comparing this most basic measure of the highway crash problem from one nation to another.

Another issue is brought up by the following question: "If alcohol is a factor in about half of the fatal crashes, why does Israel, with a low rate of alcohol abuse, have one of the highest highway fatality rates in the world?".

There are several answers. First, despite the assertion (which I personally suspect is correct) that alcohol is seldom a factor in Israeli crashes, I have seen actual data systematically collected from Israel to verify the assumption. One need only remember that for many years we heard similar assertions about the small role of alcohol in the United States and Canada and therefore have become cautious about jumping to premature conclusions. Modern Israel consists of several cultures, and different drinking patterns seem to exist even among Jews. Thus, we still await definitive data about the extent of alcohol involvement in Israel as well as in several other countries.

Of equal importance is the reference I made earlier to causal sets. We know that single causes of a disease seldom exist, that even if one cause is predominant, or even a sine qua non, other causes commonly contribute both to frequency and severity.

There are a few causes of this type that may contribute to the crash fatality problem in Israel. These, of course, may be applicable in varying degrees and combinations to other countries as well. One is the large number of new, inexperienced, and perhaps also relatively young drivers. Such populations commonly have high crash rates even in the absence of alcohol. Furthermore, because they have not yet internalized driving skills and judgments they are exceptionally sensitive to impairment by relatively small amounts of alcohol. Thus, with use of alcohol being common but abuse uncommon, alcohol may provide a moderate contribution to the highway crash rate in Israel.

Another probable contributor is the environment. Roads in Israel tend to be two lane, narrow, winding, and bordered closely by rocks. The size and mechanical condition of the vehicles varies tremendously and the drivers are from widely disparate cultural backgrounds. Desperation passing is not uncommon under these circumstances, and the environment is extraordinarily unforgiving of any errors of judgment whether because of alcohol or for any other reason.

In short, I am suggesting that the time has passed when we could be satisfied with doing epidemiologic studies of the contribution of alcohol alone. Rather, especially for international comparison, we need to know the nature and extent of other factors that simultaneously contribute to the problem. There have been extremely few such studies. Results of laboratory and simulation studies are reasonably transferable from one country to another. Work involving epidemiology in the field, however, is often not comparable unless all of the major contributing factors are well defined.

EVALUATION PROGRAMS

Yet another epidemiologic issue is the evaluation of programs and demonstration projects. The U.S. Department of Transportation is now completing a multi-million dollar demonstration program called ASAP, or "Alcohol Safety Action Projects". ASAP in the American jargon also means "as soon as possible"; and in the political tradition of federal programs, that philosophy seems to have prevailed among most – but not all – who gave the program direction.

The evaluative studies (2) that are now being published suggest that, compared to the baseline period before these projects began, there has been improvement in the countermeasure areas in some aspects of the alcohol crash problem. Unfortunately, these studies did not include consideration of what might be happening during the same time period in areas without countermeasures. In a recent report (23) from the Insurance Institute for Highway Safety, an attempt has been made to provide such a comparison and it has been concluded that the same changes were occurring in other communities without countermeasures as in the communities with countermeasures. There has been some argument whether the right communities were chosen for comparison (3). However, the important question is not whether the right comparison was chosen retrospectively, but why no attempt was made to build in such a comparison initially.

I believe I can answer this question. One ASAP project, our own Project CRASH in Vermont, does have the necessary two by two design with baseline and followup data in both countermeasure and comparable comparison areas. We were able to incorporate this design into the project and to maintain the design only by constant struggle against very great pressures from federal government, within the state, and even within the project. Our data were not included in the Department of Transportation report, and we are not yet ready to present completed results, although there are several promising aspects of our preliminary results.

The point, of course, is that evaluation is one of the most important current uses of epidemiology, and that there is no satisfactory substitute for the two by two evaluation design and none should be attempted. Yet, after 75 years of action without evaluation, we still do not appear to have learned the necessary lessons.

Another lesson to be learned concerns the use of data containing false negatives and false positives. A person who survives for hours or days after injury may have no alcohol in his blood at time of death, not because he hadn't been drinking, but because the alcohol he consumed had long since been metabolized. When these survivors are included in data about people who do or do not have alcohol a very high proportion of false negatives occurs. Therefore, most studies of the presence of alcohol are now limited to persons who died within six hours after injury and to persons aged 15 or older.

Zylman (24) has correctly pointed out, however, that one effect of excluding persons who survive for more than 6 hours is to overload the excluded group with elderly persons who tend to have alcohol less often than the rest of the population. I estimate that this error probably results in less than a 4-5% overinflation of the role of alcohol in highways crashes. However, as in the case of death rates discussed earlier, the techniques of standardizing the result by means of age correction are well known, and I would urge that an ad hoc committee be formed to present the 7th conference on alcohol drugs and traffic safety with appropriate guidelines for applying such corrections in future reporting.

Unfortunately, in describing the problem of excluding the elderly, much of Zylman's discussion leaves the impression that exclusion of persons who died six hours or more after injury is *entirely* inappropriate no matter what the age group. Other errors in Zylman's work include the failure to distinguish in his analyses between persons who initiate crashes and those who are innocent victims. The Distilled Spirits Council of the United States (DISCUS) has given his statements such wide publicity, suggesting that alcohol is nowhere near the problem that the scientific community has been saying it is, that it has become imperative that his methodologic mistakes be given equally wide publicity.

Another place where this error of false negatives occurs is in the correlation between high BAC and fatty changes of the liver. As pointed out in our original paper (16) on this subject, persons under age 25, no matter how serious a drinking problem they might have, are extremely unlikely to have visible fatty changes of the liver.

Therefore, because of the high likelihood of false negatives in this age group, any attempt to correlate fatty changes and problem drinking among persons with BACs of 100 mg/100 ml or higher must be limited to those age 25 or older. Zylman (25) and others (20) have not done this and, therefore, in my opinion have reached erroneous conclusions about a lack of correlation.

MARIHUANA AND HIGHWAY SAFETY

Finally, let us examine what is known from the epidemiologic viewpoint about marihuana and its products and highway safety. Ideally, it would be useful to be able to compare actual concentrations of tetrahydrocannabinol (THC) or other drugs among persons who have just been involved in crashes of various types and among drivers exposed to similar circumstances of time and place but not involved in crashes. This type of design, of course, was first reported in studies of alcohol by Holcomb (9) in 1938 and was brought to fruition with the work of Haddon and his associates (8, 10), and by Borkenstein and his associates (5). To my knowledge, it has not been repeated perfectly with any other drugs.

However, in some cases – for example, with tranquilizers and barbiturates – enough data exist concerning the usual prevalence of these drugs in the population. Thus it is fairly apparent from the several studies of the part played by these drugs in highway fatalities that they are not substantially overrepresented in the cause of fatalities (11, 17). With marihuana, however, there are different problems. First, a truly adequate method of testing for THC in the blood does not exist. The techniques currently being used by Midwest Research Institute (22), under contract with the U.S. Department of Transportation, still appear to have possible substantial problems involving false negatives and false positives. Also, there are no really accurate data about the prevalence of marihuana use, especially in relation to driving; and whatever the prevalence is, it appears to be changing from one year to the next.

Yet another problem is the reported shift in use patterns from consumption of marihuana alone during the 1960s to frequent consumption in combination with alcohol during the 1970s. Thus, even if crashes were found to be overrepresented among marihuana users who also used alcohol we would have to ask whether the overrepresentation was attributable to the marihuana, to the alcohol, or to both.

There are some studies which may bring us a bit closer to answering these questions. Several years ago, for example, I studied annual crash rates per unit miles travelled among persons with various potentially impairing conditions including illegal use of drugs, and among drivers of similar age and sex without such conditions (15). It was concluded that drivers using marihuana and various other drugs did not have an increase in crash risk. Other work by different researchers (12) has supported this conclusion for all except persons addicted to amphetamines.

In the absence of a method to actually test for marihuana we turned to a more sophisticated version of the 1966 study, which now involved the driving experience of two freshman classes at the University of Vermont. Freshmen were given a national student profile questionnaire which most completed shortly after arrival at school. We gave all students participating in this profile an additional questionnaire about marihuana, alcohol, and other drugs and driving which they completed anonymously and returned before they left the testing center. Ninety-seven percent of the students completed this questionnaire, giving us a sample of over 1200 students in 1972 and over 1500 the next year. Only the results will be discussed here rather than the methodology. We do have good reason to believe, though, that the answers we received were an honest attempt by the students to describe their experiences.

In 1969 a study (13) showed that 28% of all students on the University of Vermont campus used marihuana in the previous year. By 1972 this had risen to 49% of the freshman class and by 1973 to 57% of freshmen. Only 11% of all freshmen, or 20% of users, were consuming more often than weekly, however.

The following data are from the 1972 study (19). Among users 47% did not drive at all or did not drive after using marihuana, and another 31% drove while 'high' less than once a month. On the other hand, 11% of users reported that they drove several times a week while high. Most important, the heaviest users of marihuana were also the ones who most often consumed potentially impairing amounts of alcohol (*i.e.* 3 or more drinks) in conjunction with smoking and who drove after using these two drugs. Thus, persons who used marihuana daily represent 5% of users with drivers' licenses, 33% of all driving trips after marihuana and 49% of driving after combined use of marihuana and 3 or more drinks of alcohol.

What effect did users say marihuana had on their driving? Thirty-three percent reported no effect and 10% said it made them better drivers. However, 17% said it altered their time sense, 22% that it affected vision or attention span, and another 18% that it had other or combined effects. Users commonly reported that they drove more cautiously after using marihuana but less cautiously after using alcohol, an assessment that is consistent with some simulation studies (12). In the second study, we listed those who reported more cautious driving as a separate group.

In the first study we identified a total of 4 crashes and 42 near crashes that were reported to have occurred under the influence of marihuana. About 60% of these appeared to be directly attributable to marihuana, and 27% to alcohol, while in the remainder the cause was not ascertained. Interestingly, drivers who reported that marihuana affected time sense only were less likely to have near crashes than were those who reported other negative effects, such as on vision or attention span.

Because we did not have good information from the first study as to whether the crash and near crash rates after using marihuana were excessive or not, we collected information in the 1973 study about annual mileage, crashes, near crashes, traffic citations and occasions when these drivers almost got a ticket with and without use of marihuana. The second study is still being analyzed, but preliminary data are now available. Overall, 11% of annual mileage was reported to have occurred within 2 hours after using marihuana. Whether the criterion was crashes, near crashes, citations, or near citations the rates per unit mile travelled were similar for the 7.6 million miles without marihuana and the .9 million miles with the drug.

As in the first study, we found important differences in near crashes after marihuana use according to the usual effect that the driver reported the drug had on him. Thus, the rate of near crashes without marihuana was 12 per 100,000 miles. With marihuana it was from 2-5 per 100,000 miles for those who said marihuana either had no effect or improved their driving, and from 5-13 for persons who had only altered time sense or who said the net effect was that they drove more cautiously. However, in keeping with the first study, among those who reported that marihuana adversely affects vision, attention span, judgment or causes combined effects, the near crash rate was 30 per 100,000 miles. These latter effects are the same that have been documented to occur with alcohol.

It is possible, of course, that persons who are high on marihuana are less likely to be aware of or remember problems that occur while they are driving. Recent simulation studies (6), however, suggest that this is not the case. Assuming these data are reasonably accurate, how should they be interpreted in relation to the model of frequency and quantity of deviancy? First, although many people are using marihuana, the relative mileage is low considering that the data are from that age group representing most frequent users. Based on student statements, marihuana does have effects that are perceived by them to be impairing, but substantially less so than for alcohol. Nevertheless, several crashes and near crashes could be attributed to the effects of the drug per se. These do not appear to be sufficient in quantity to result in excessive risk at this time.

Of particular concern, however, are those persons who report that marihuana adversely affects vision, attention span, or judgment. These are functions that are impaired by alcohol, and the combined use of alcohol and marihuana by such persons, in my opinion, cannot help but increase their crash risk. Thus, I would cautiously conclude that marihuana is likely to create a crash risk predominantly when used in conjunction with alcohol, a pattern that unfortunately appears to be increasingly popular. The impairment in this case would probably result from the combined effects of both drugs and would be most serious in persons who have similar types of effects from both drugs.

SUMMARY

Two problems currently relevant to the epidemiology of alcohol, other drugs, and highway safety have been considered. One is the need to set priorities for research and action; a model of frequency and quantity of deviancy has been proposed to provide a guide. Based on this model, only alcohol, marihuana and tobacco can be identified as of potentially major importance to highway safety at this time and on this continent, and alcohol appears to contribute to the hazard of the latter two.

The other problem is the interspersing of the literature with data that are of unknown comparability. This includes varying definitions of a highway fatality, failure of studies to include environmental and other variables that may interact with alcohol and other drugs, evaluation studies that do not use a two by two design, and data that contain large numbers of false negatives and false positives.

REFERENCES

1. Adams, J. R., Oral Habits and Traffic Accidents: Overdependency as an Explanatory Construct, *Proceedings of Fourth International Conference on Alcohol and Traffic Safety.* Department of Police Administration, Indiana University, Bloomington, Indiana, 1966, pp 41-49.
2. *Alcohol Safety Action Projects, Evaluation of Operations – 1972, Volume II, Detailed Analysis.* Office of Alcohol Countermeasures, National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C.
3. ASAP Effectiveness, *National Traffic Safety Newsletter*, August 1974. National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C. p. 10.
4. Beard, R. R. and Wertheim, G., Behavioral Impairment Associated with Small Doses of Carbon Monoxide *American Journal of Public Health* 57, 2012 (1967).
5. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B. and Zylman, R., *The Role of the Drinking Driver in Traffic Accidents.* Department of Police Administration, Indiana University, Bloomington, Indiana, 1964.
6. Dott, A. B., *Effects of Marihuana on Risk Acceptance in Simulated Driving Tasks.* Injury Control Research Laboratory, Research Report 71-3, Providence, Rhode Island, 1971.

7. Douglass, R. L., and Filkins, L. D., *The Effect of Lower Legal Drinking Ages on Youth Crash Involvement – Final Summary Report.* National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C., March 1974.

8. Haddon, W. Jr., Valien, P., McCarroll, J. R., and Umberger, C. J., A Controlled Investigation of the Characteristics of Adult Pedestrians Fatally Injured by Motor Vehicles in Manhattan *Journal of Chronic Diseases* 14, 655-678 (1961).

9. Holcomb, R. L., Alcohol in Relation to Traffic Accidents, *Journal of the American Medical Association* 111, 1076-1085 (1938).

10. McCarroll, J. R. and Haddon, W. Jr., A Controlled Study of Fatal Automobile Accidents in New York City *Journal of Chronic Diseases* 15, 811-826 (1962).

11. Nichols, J. L., *Drug Use and Highway Safety: A Review of the Literature.* Report DOT-HS-012-1-019 U.S. Department of Transportation, Washington, D.C., 1971.

12. Smart, R. G., Schmidt, W. and Bateman, K., Psychoactive Drugs and Traffic Accidents. *Journal of Safety Research* 1, 67-73 (1969).

13. Steffenhagen, R. A., Unpublished data from Project DART, Department of Sociology, University of Vermont, Burlington.

14. U.S. Department of Health, Education and Welfare, *Smoking and Health, Report of the Advisory Committee to the Surgeon General of the Public Health Service.* (PHS Publ #1103), U.S. Government Printing Office, Washington, D.C., 1964.

15. Waller, J. A., Chronic Medical Conditions and Traffic Safety: A Review of California Experience. *New England Journal of Medicine* 273, 1413-1420 (1965).

16. Waller, J. A. and Turkel, H. W., Alcoholism and Traffic Deaths, *New England Journal of Medicine*275, 532-536 (1966).

17. Waller, J. A., Drugs and Highway Crashes *Journal of the American Medical Association* 215, 1477-1482 (1971).

18. Waller, J. A. and Thomas, K., Carbon Monoxide, Smoking, and Fatal Highway Crashes *Proceedings of Fifteenth Conference of the American Association for Automotive Medicine.* Society of Automotive Engineers, New York, New York. 1972.

19. Waller, J. A., Lamborn, K. R., and Steffenhagan, R. A., Marihuana and Driving Among Teenagers: Reported Use Patterns, Effects, and Experiences Related to Driving. *Accident Analysis and Prevention* (in press).

20. Whitlock, F. A., Armstrong, J. L., Tonge, J. I., O'Reilly, M.J.J., Davison, A., Johnson, N. G. and Biltoff, R. P., The Drinking Driver or the Driving Drinker? *Medical Journal of Australia* 2, 5-16 (1971).

21. Williams, A. F., Rich, R. F., Zador, P. L., and Robertson, L. S., *The Legal Minimum Drinking Age and Fatal Motor Vehicle Crashes.* Insurance Institute for Highway Safety, Washington, D.C. 1974.

22. Woodhouse, E. J., *The Incidence of Drugs in Fatally Injured Drivers.* Midwest Research Institute, Kansas City, Missouri. Final Report on Contract No. DOT-HS-119-1-627, U.S. Department of Transportation, February 1974.

23. Zador, P., *Statistical Evaluation of the Effectiveness of "Alcohol Safety Action Programs".* Insurance Institute for Highway Safety, Washington, D.C. 1974.

24. Zylman, R., Overemphasis on Alcohol May Be Costing Lives, Presented at *80th Annual Conference of the International Association of Chiefs of Police*, San Antonio, Texas, September 23, 1973.

25. Zylman, R., Semantic Gymnastics in Alcohol-Highway Crash Research and Public Information. *Journal of Alcohol and Drug Education* 19, 7-23, (Winter 1974).

Alcoholics and Social Drinkers: Characteristics and Differentiation

Melvin L. Selzer[1]

The percentage of drunk drivers who are alcoholics and/or problem drinkers remains a latter day conundrum. Although that particular controversy is not the subject of this paper, it does intrigue me and I would like to devote some time to it. However, I am not as certain of my convictions on this subject now as I was ten years ago.

The work of a number of American and Canadian investigators points to a high percentage of alcoholics in groups apprehended for drunk or impaired driving (8, 10, 13, 17, 18). That percentage ranges up to 60% and generally can be said to be substantial.

Some researchers have contended that alcoholism was not a prominent feature in their drunk driver groups, despite the fact that the first research strongly linking alcoholism with drunk driving took place in Sweden as far back as 1955 (3). Unfortunately, too many people have remained dedicated to an exclusively simplistic and punitive approach to the drunk driving problem.

Law enforcement and traffic safety personnel have also generally tended to resist the notion that many drunk drivers have chronic drinking problems. One cannot blame them, since enforcement is difficult enough without thinking about the complexities of drug dependence, substance abuse, emotional illness, and so forth.

In effect, we still have a dispute about the number of pathological drinkers found in drunk driver populations. The phenomenon of different investigators looking at similar events and somehow reporting a variety of disparate data and drawing widely differing conclusions, is by no means peculiar to the study of drunk driving. A number of possibilities to account for these discrepancies come to mind, although answers will not emerge until research using identical methods is conducted in several countries.

The most obvious possibility is that different areas of the world do indeed present genuinely different mixtures of social drinkers and alcohol abusers in their drunk driving populations. Another is that there still exist very different criteria for alcoholism in different parts of the world. A driver labeled alcoholic in one jurisdiction may be viewed as a weak-willed playboy or thoughtless social drinker elsewhere. Recent discussions with colleagues and government officials in France brought out the fact that although they consider alcoholism to be a serious problem in France, many of them felt that over half the population of excessive drinkers in France had no real problem but had merely acquired an excessive drinking habit because of the availability of large amounts of inexpensive wine. One suspects that we in the United States would classify many of these as alcoholics, while our French colleagues would not.

---

[1] Professor of Psychiatry, University of Michigan Medical School, Ann Arbor, Michigan, 48104, U.S.A.

This brings us to another possible reason for variations in results concerning the number of alcoholics or problem drinkers in a drunk driving population, a reason directly related to the subject of this paper. It is quite likely that many alcoholics are not identified in drunk driving programs either because they are not sought for at all, or inadequate methods are used in that search. Indeed, it is still customary in many programs not to consider the possibility of an alcohol related illness until multiple arrests for drunk driving have taken place. (This is known as the "inescapable conclusion method.")

During the period my colleagues and I were demonstrating that alcoholics were overrepresented in the ranks of drunk drivers, we were not infrequently queried as to why we were bothering to make the effort. This type of inquiry came from two sources. One was the traditionalists bent on punishing their guilty prey and fearful that labeling them as alcoholics was tantamount to another form of coddling. Others, who were interested in alcoholism as such, were simply not intrigued with the alcoholics' mode of transportation and were faintly surprised that I was. In retrospect, I believe their unspoken message was, "Let's cure his alcoholism and his drunken driving will become a moot point." Unfortunately it is not that simple.

Since even the most skeptical now acknowledge that drunk driving populations harbor substantial numbers of alcoholics, we should in effect put ourselves in a position to guide or coerce as many of them as possible into rehabilitation programs. Furthermore, I believe that alcoholism treatment programs are generally becoming more effective and more widespread. The implications for traffic safety are obvious.

To treat an alcoholic one must first develop the means for distinguishing him or her from the social drinker. Surprisingly, this is not necessarily an automatic or simple task. Alcoholics, particularly those whose families and jobs appear intact, can resolutely maintain and almost prove they do not have a drinking problem. This conscious process is often aided by the unconscious defense mechanism of denial. There are alcoholics whose unconscious denial systems operate to convince themselves and others they do not have a drinking problem. If a man can deceive himself, deceiving others becomes a relatively easy task. Moore has pointed out that many alcoholics need a denial system in order to continue drinking with at least a modicum of comfort (7). If they acknowledge to themselves that a drinking problem exists, then they must reflect on the need to give up drinking: a grim prospect for the alcoholic. Denial obviates this unpleasant dilemma through its unconsciously self-imposed ignorance.

Doubtless, there are other forces operating which prevent us from detecting alcoholism in drunk drivers and others. I am convinced many professional people simply do not want to discover that the patients, clients, applicants or drivers they deal with are alcoholics. It is simpler not to know because to know complicates our techniques and procedures, forces us to reflect and creates dilemmas that are not always easy to resolve. In effect, it is again a subtle form of unconscious denial, this time on the part of those dealing with alcoholics. Six years ago an alcoholism survey was done on all patients admitted to two internal medicine wards of the University of Michigan Hospital. Some 20% of the 79 male patients and 8% of the 83 female patients were diagnosed as alcoholics by the survey team. However, only half those diagnosed as alcoholics by the survey team were discovered to be alcoholics by the ward medical staff. Making a diagnosis of alcoholism is more elusive than commonly thought.

There are other natural barriers to recognizing alcoholism that are worth noting. Although almost everyone now knows that the image of the alcoholic as a skid row inhabitant is false, it is still considerably more difficult to recognize the middle class alcoholic than his blue collar counterpart. Of course, the middle class alcoholic usually has better mastery of his surroundings, can more successfully evade detection, and if detected can more readily evade or postpone social sanctions. All of these factors contribute to his ability to obscure his alcohol problem.

These remarks concerning the middle class male alcoholic apply all the more to his female counterpart. A number of factors protect the female from detection but foremost is her gender and its genteel image as contrasted to our own expectations about 'drunks'. If she is a housewife she can deploy many more subterfuges, not having to meet the schedules of office and plant. Her 'employers', namely husband and family, are apt to be considerably more dilatory than would a plant foreman in coercing her into treatment. Her alcoholism may pass unnoticed in the outside world until she is well into grandmotherhood.

Unlike narcotic addicts, alcoholics may vary the amount of their drinking, drinking mostly on weekends or in periodic binges. When under pressure, or made ill by prolonged intoxication, some alcoholics can, and do, stop drinking for a while and will attest they do not even miss drinking. It is important that we do not overlook those who possess this flexible form of alcoholism.

A remarkable number of alcoholics become and remain alcoholic on beer alone (12). Approximately 25% of alcoholics in the U.S. are beer alcoholics. This varies with social class, and I presume similar data would be found in other beer drinking countries. The alcohol content of beer is sufficient to build up gratifying blood alcohol concentrations, depress cortical centers and maintain a chronic state of alcoholism (4). The alcoholic beer drinker may use his predilection for beer to successfully persuade himself and others that he couldn't possibly have a drinking problem.

ON MAKING A DIAGNOSIS OF ALCOHOLISM

I shall forego any effort to critically define alcoholism. Rather, this paper will be devoted to specific criteria for making a diagnosis of alcoholism. When any known common etiological mechanisms are absent, a disease or group of diseases can only be described rather than defined. Alcoholism is a pathological dependency on beverage alcohol, it involves excessive use of alcohol and it causes harm to the drinker's health or to his social and economic well being.

I shall use problem drinking as a synonym for alcoholism although I do not like the term 'problem'. It tends to make alcoholism seem trivial; after all, we all have 'problems'. Furthermore, no clear cut boundary between alcoholism and problem drinking has been defined.

Alcoholism has been diagnosed or defined in a number of ways. These include definitions based on 1) quantity imbibed, 2) degree of loss of control, 3) social consequences, 4) physiological and clinical criteria and 5) psychological parameters. The choice of diagnostic criteria has often been directly influenced by the goals of those using the criteria. These goals may vary: desire for early detection, establishing a prognosis, or absolute certainty of diagnosis may be paramount. A group of criteria designed to fulfil one diagnostic goal may automatically obscure the desired information needed for other goals. For example, some studies have been based on a diagnosis of alcoholism made exclusively by determining if subjects received treatment for alcoholism and/or were arrested for alcohol-related misdemeanors, and/or whether they or their family appeared at social agencies to voice alcohol-related complaints. This method does assure the subjects labeled as alcoholic are exactly that. Unfortunately, it also ensures that a large number of alcoholic subjects are overlooked. It is also a very costly method and given the increasingly stringent confidentiality regulations everywhere, I suspect record searches of public agencies will soon be a thing of the past.

Quantity of Alcohol Imbibed

Using the amount of beverage alcohol consumed each day, week or sitting, to make a diagnosis of alcoholism has two major drawbacks. One is the lack of guidelines for how much alcohol one must consume to be thought alcoholic. Extreme parameters are no problem since most people would agree that a person who consumes a fifth of a gallon of whiskey nightly is undoubtedly an alcoholic. The problem lies at the interface between excessive and normal drinking. Is a person who becomes mildly intoxicated three times a week without seeming to harm himself or others an alcoholic?

Reaching a diagnosis based on alcohol consumption is further complicated by group and cultural influences. Suppose a man were to get intoxicated periodically but neither the drinker, his family nor his associates perceived a problem? What basis would there be to postulate a problem unless we could demonstrate physical disease consequences?

Some experts have gone so far as to state that "drunkenness per se is not equivalent to alcoholism if it is not idiosyncratic for the individual or disapproved of, either by the group or by the individual's own conscience" (9, p14). In effect, this could mean that the periodic consumption of a large amount of alcohol in one context can result in different labeling of the drinker than if consumed in another context, and so forth.

The second problem inherent in using quantities of alcohol consumed as a criteria for alcoholism is that the answers received from the alcoholic often tend to be vague, inaccurate or deceptive. Many alcoholics simply reduce the amount they think they drink when queried; whether by design is difficult to say. Clinicians often note that with more intensive questioning, many alcoholics acknowledge greater intake. Hence, using the amount of alcohol consumed as part of a program to detect alcoholism may or may not be contributory. All this is not to imply that accurate information (when obtained), regarding frequent excessive consumption and intoxication is not a highly significant criterion for alcoholism.

Physiological and Clinical Criteria

Although of limited value in screening procedures and of even less value for early detection, physiological and clinical criteria are important factors in diagnosis. Alcohol-associated illnesses often develop in alcoholics and may affect the gastrointestinal tract and nervous system, as well as the hemopoietic and clotting mechanisms.

Unfortunately, there are no specific physical or laboratory criteria for alcoholism. Although there are indeed subtle to gross physiological and neurological derangements associated with alcoholism, they are variable, often late, and may never appear at all in some alcoholics.

Many people sincerely believe there are 'physical' causes of alcoholism and this may foster the belief there are reliable physical findings. I know of no physical 'causes' of alcoholism, although the converse is often true.

Evidence of increasing tolerance to the effects of alcohol may also constitute an important criterion. These include 1) a blood alcohol level of more than 150 mg/100 ml without gross evidence of intoxication and 2) consumption of one-fifth of a gallon spirits or its alcohol equivalent in beer or wine daily for more than one day (1). I might add that this tolerance seen in many alcoholics is one reason why any plans for an alcohol-related ignition interlock system in automobiles were foredoomed to failure. An intoxicated alcoholic may be as dextrous as a sober non-alcoholic.

Psychological and Behavioral Criteria

The possibility of developing reliable psychological or psychiatric criteria for alcoholism has long intrigued the mental health fraternity. Methods based on very broad criteria relating to orality, dependency, alienation and even unconscious homosexual proclivity have all made their way into the literature. Clinical observations and psychological testing have found a high incidence of various manifestations of psychopathology in alcoholic populations. These include depression, poor reality testing, impulsivity, struggle with dominance-submission and activity-passivity conflicts and many others. Unfortunately, although many of these factors are indeed present in a high percentage of alcoholics, they are by no means specific to alcoholic populations. Nor is any combination of psychological factors sufficiently specific to alcoholism to serve as a convincing diagnostic tool. All we may assume is that a well adjusted person is unlikely to drink regularly to excess and is far less likely to become alcoholic.

In addition to directly alcohol-related behavior which will be discussed later in this paper, a number of behavioral changes seen in alcoholics are worth mentioning. These include frequent excuses from work for a variety of reasons, lack of interest in activities not associated with drinking and any unexplained changes in family, social or work relationships.

Alcohol-Related Behavior

Although many of the criteria already mentioned in this paper are reasonably firm criteria of alcoholism, most of them have drawbacks. The best means of detecting alcoholism is a combination of the most diagnostic and frequently occurring factors with considerable reliance on those that are a direct consequence of excessive and chronic drinking. Although many criteria are not diagnostic in and of themselves, the discovery of several such criteria can virtually confirm the presence of alcoholism. On the other hand, there are some criteria that are diagnostic and these would have to be part of any diagnostic schema even though they may occur infrequently. The list of criteria should be so constituted that third parties (*i.e.*, family, associates) can provide information indicating the presence or absence of alcoholism.

Although there are a number of such drinking behavior scales and inventories I shall use the Michigan Alcoholism Screen Test (MAST) as a prototype for this kind of screening instrument because I am most familiar with it, having formulated it in 1970 (11). It has the advantage of having been used by a number of clinicians and researchers who have commented on its advantages and shortcomings (5, 6, 13, 14, 16).

The MAST now consists of 24 questions that can be administered or self-administered in 10 to 15 minutes (Appendix A). It was devised to meet a number of objectives. It had to be easy to administer, non-time consuming and most important, have a simple comprehensible scoring system which did not require the presence of a statistician or a computer bank. The scoring system ultimately selected gave each question a weighted value based on its discriminatory power with the three 5 point questions considered as diagnostic. The scoring system providing the most accurate selection was: 0-3 points – non-alcoholic; 4 points – suggestive of alcoholism; 5 points and over – alcoholic.

One problem that had to be faced when formulating the MAST was whether alcoholics, particularly those caught in traffic-related transgressions, would be sufficiently candid about answering such obvious questions. An early clue was provided when we ran a "fake-take" at a nearby hospital for alcoholics. All of the 99 male alcoholic subjects were carefully and individually instructed to lie about their alcohol problem, in effect to cover up. Despite these instructions, 92% of the subjects scored in the alcoholic range (4). Others using the MAST also reported that there was little problem with subject candor. However, it would be misleading to deny that an alcoholic could answer the questions and keep his secret intact. Indeed, in my original MAST paper I reported on 15 alcoholics who did just that (11). However, most alcoholics do not avoid truthful answers and this has been one of the surprises in using the MAST.

However, there are difficulties, to the effect that the MAST may be too sensitive. One of the early complaints was that too many subjects were scoring in the alcoholic range, that is 5 or more points. Indeed, when we ourselves then administered the MAST to 100 male subjects after they had routinely renewed their driver licenses, (with another 100 refusing the questionnaire) 16% scored in the alcoholic range. There are a number of possible explanations for so high a total and I suspect all are partially applicable. 1. The MAST is somewhat too sensitive and may misclassify a few social drinkers as alcoholic. 2. Respondents do not clearly understand some questions and provide the wrong answers. 3. There are more alcoholics in the adult male population than was previously realized.

Let me reiterate at this point that the MAST is a screening instrument. However, with each point total above 5 the diagnosis becomes more of a certainty. I should add that since the questions are timeless, anyone who indicates that all of his alcohol-related responses are exclusively in the past would not be considered an alcoholic.

A paper now in press indicates that the MAST is useful as a self-administered instrument and has both high reliability (alpha = .95) and validity (r=.90) (15). Furthermore, it does not appear to be unduly influenced by the subjects' defensiveness. In short, it is a useful instrument for screening for alcoholism.

APPENDIX A Revised Michigan Alcoholism Screening Test

Below is a series of questions related to drinking. Please answer each question by checking the appropriate column.

Questions	Answers with Weighted Scoring	
	YES	NO
1. Do you feel you are a normal drinker? (By normal we mean you drink less than or as much as most other people).		2
2. Have you ever awakened the morning after some		

	drinking the night before and found that you could not remember a part of the evening?	2	
3.	Does your wife, husband, a parent, or other near relative ever worry or complain about your drinking?	1	
4.	Can you stop drinking without a struggle after one or two drinks?		2
5.	Do you ever feel guilty about your drinking?	1	
6.	Do friends or relatives think you are a normal drinker?		2
7.	Are you able to stop drinking when you want to?		2
8.	Have you ever attended a meeting of Alcoholics Anonymous?	5	
9.	Have you ever gotten into physical fights when drinking?	1	
10.	Has drinking ever created problems between you and your wife, husband, a parent, or other near relative?	2	
11.	Has your wife, husband, a parent, or other near relative ever gone to anyone for help about your drinking?	2	
12.	Have you ever lost friends or girl friends because of your drinking?	2	
13.	Have you ever gotten into trouble at work because of drinking?	2	
14.	Have you ever lost a job because of drinking?	2	
15.	Have you ever neglected your obligations, your family, or your work for two or more days in a row because you were drinking?	2	
16.	Do you drink before noon fairly often?	1	
17.	Have you ever been told you have liver trouble? Cirrhosis?	2	
18.	After heavy drinking have you ever had Delirium Tremens (D.T.'s) or severe shaking, or heard voices or seen things that weren't really there?	2	
19.	Have you ever gone to anyone for help about your drinking?	5	
20.	Have you ever been in a hospital because of drinking?	5	
21.	Have you ever been a patient in a psychiatric hospital or on a psychiatric ward of a general hospital where drinking was part of the problem that resulted in hospitalization?	2	
22.	Have you ever been seen at a psychiatric or mental health clinic or gone to any doctor, social worker, or		

clergyman for help with any emotional problem, where drinking was part of the problem?	2	
23. Have you ever been arrested for drunk driving, driving while intoxicated, or driving under the influence of alcoholic beverages?	2	
24. Have you ever been arrested, even for a few hours, because of other drunk behavior?	2	

REFERENCES

1. Criteria Committee, National Council on Alcoholism, Criteria for the Diagnosis of Alcoholism, *American Journal of Psychiatry*, 129, 127-135 (1972).
2. Ehrlich, N. J. and Selzer, M. L., *A Screening Program to Detect Alcoholism in Traffic Offenders, in the Prevention of Highway Injury.* Edited by Selzer, M. L., Gikas, P. W. and Hueke, D. F., Ann Arbor, University of Michigan, Highway Safety Research Institute, 1967, pp. 44-50.
3. Goldberg, L., Drunken Drivers in Sweden, *Proceedings of the 2nd International Conference on Alcohol and Road Traffic*, Toronto, 1955.
4. Lolli, G., Schesler, E., and Golder, G., Choice of Alcoholic Beverage Among 105 Alcoholics in New York, *Quarterly Journal of Studies on Alcohol,* 22, 475 (1960).
5. Moore, R. A., The Prevalence of Alcoholism in a Community General Hospital, *American Journal of Psychiatry,* 128, 638-639 (1971).
6. Moore, R. A., The Diagnosis of Alcoholism in a Psychiatric Hospital, A Trial of the Michigan Alcoholism Screening Test (MAST), *American Journal of Psychiatry,* 128, 1565-1569 (1972).
7. Moore, R. A. and Murphy, T., Denial of Alcoholism as an Obstacle to Recovery, *Quarterly Journal of Studies on Alcohol,* 22, 597-609 (1961).
8. Popham, R. E., Alcoholism and Traffic Accidents, *Quarterly Journal of Studies on Alcohol,* 17, 225-232 (1956).
9. Research Plan, Drinking Practices Study, Mental Research Institute, Berkeley, California, mimeograph.
10. Schmidt, W. S. and Smart, R. G., Alcoholics, Drinking and Traffic Accidents, *Quarterly Journal of Studies on Alcohol,* 20, 631-634 (1959).
11. Selzer, M. L., The Michigan Alcoholism Screening Test: The Quest for a New Diagnostic Instrument, *American Journal of Psychiatry,* 127, 1653-1658 (1971).
12. Selzer, M. L. and Holloway, W. H., A Follow Up of Alcoholics Committed to a State Hospital, *Quarterly Journal of Studies on Alcohol,* 18, 98-120 (1957).
13. Selzer, M. L., Payne, C. E., Kelly, W., and Gifford, J., Alcoholism, Mental Illness and the Drunk Driver, *American Journal of Psychiatry,* 120, 311-326 (1963).
14. Selzer, M. L., Vanosdall, F. E., and Chapman, M., Alcoholism in a Problem Driver Group, *Journal of Safety Research,* 3, 176-181 (1971).
15. Selzer, M. L., Vinokur, A., and Van Rooijan, L., A Self-Administered Short Michigan Alcoholism Screening Test (SMAST), *Quarterly Journal of Studies on Alcohol,* December 1974 (In press).
16. Tamerin, J. S., Tolor, A., DeWolfe, J., Packer, L., and Neumann, C. P., Spouses Perceptions of Their Alcoholic Partners: A Retrospective View of Alcoholics by Themselves and Their Spouses, *Third Annual Alcoholism Conference of the National Institute on Alcohol Abuse and Alcoholism*, Washington, D.C., 1973 (In Press).
17. Waller, J. A., Identification of Problem Drinking Among Drunken Drivers, *Journal of the American Medical Association,* 200, 124-130 (1967).
18. Yoder, R. D. and Moore, R. A., Characteristics of Convicted Drunken Drivers, *Quarterly Journal of Studies on Alcohol,* 34, 927-936 (1973).

Roadside Surveys, Demographics and BACs of Drivers

Robert B. Voas[1]

When organizing our perceptions, that which is perceived can be divided into figure and ground. In traffic safety research, the 'figure' that stands out from the 'ground' is the crash. The crash destroys property; it injures, maims and kills people. It is brought vividly to our consciousness when we think of traffic safety. It stands out and all other elements of the vehicle, driver and roadway environment become back-ground. If, however, we lose awareness of the driver, vehicle, roadway 'background' we may come to a very fundamental misunderstanding of the nature of the crash phenomena with which we are dealing.

BACKGROUND VARIABLES

Male versus Female

If we consider fatal crashes involving teenage drivers that occur at night, 87 per cent of these involve male drivers, while only 13 per cent involve females. Focusing only on the crash event, the mind leaps immediately to the conclusion that men are six times more 'accident prone' than women. Of course more men are licensed to drive than are women, but the disparity is not too great. Fifty-six per cent of drivers under 20 years of age are estimated to be male as compared to 44 per cent female in the United States. Even when we correct for this, it appears that teenage men are four to five times more at risk than their female counterparts. The hazard rating of men will be corrected if we go out and take a random sample of night-time drivers. When we do this, we find that nearly eight out of ten are males. This is a natural consequence of our social mores in the United States, which call for the male to do most of the driving particularly in after-hour social activities.

As far as young persons are concerned, young men are still at higher risk of having a night-time crash then young women. But the ratio has dropped to less than two to one. By measuring the background conditions, *i.e.*, the number of male to female drivers, our understanding of the male involvement in fatal night-time crashes has been significantly altered.

---

[1] Chief, Evaluation Division, Office of Alcohol Countermeasure, Traffic Safety Programs, U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, D.C. 20590, U.S.A.

Driver Groups

We can roughly, and somewhat arbitrarily, divide the driving population in terms of alcohol-related factors into four major groups. There is, first of all, the small group of drivers who become involved in fatal crashes and for whom we have blood alcohol measurements. There is a somewhat larger group of drivers who are apprehended for drinking/driving and are required to take a chemical test. Both of these groups are drawn from the much larger group of drivers who have alcohol in their systems. This group comprises small fraction to perhaps just under half of all drivers on the road, depending on the time of day and the day of the week, and other factors described below. It is this group of drinking drivers who are neither crash-involved nor arrested (at least at the time they are interviewed and measured), who are the subject of this paper. I shall try to describe certain of the vehicle, environment and driver behavior factors which are typical of this group. Also to be discussed are how measurements of the non-crash involved driver can be useful both in research and in the measurement of the effectiveness of operational programs.

Exposure and Causality

Most crashes result from a combination of several factors. A drunk driver on his way home, in the rain, tries to take a short curve too fast. He skids, hits a signpost, goes through the windshield and is killed. There are a series of elements which produce the event; which one caused the crash? Had the driver been sober and not drunk, might he have taken the curve at a more leisurely pace and, if he began to skid, might he have taken action to overcome the skid more rapidly? On the other hand, given that the driver was drunk, if the curve had not been so sharp, the pavement not so wet, perhaps he would not have left the road even though his driving was impaired. In either of these events there might have been no injury had there not been a signpost to crash the vehicle.

Each of these elements can be viewed as having been necessary to produce the crash but each one, in itself, is not significant. Measuring the ‘background’ of the traffic environment provides information on the frequency of those ‘elements’ which are necessary to the occurrence of accidents, but which at the time of measurement have not combined with the other elements that produce an accident. To determine the significance of the behavior of ‘element’ in crash production we must understand the frequency of the behavior in noncrash-involved drivers.

BAC

In concept, any item of driver behavior can be related to crash involvement. However, in practice most types of driver behavior have not been measured consistently in both the crash and noncrash population. Blood alcohol concentration (BAC) provides a number of advantages for this purpose. In contrast to other types of behavior, such as attention, excitement, or distraction, which are labile and difficult to measure, BAC is relatively stable. The evidence is preserved beyond the period of the crash for some hours. This permits measurement of this piece of driver behavior while other items are not subject to capture following the crash. For this reason, BAC has been subject to wider study than any other piece of driver behavior. It is possible that this relative ease of investigation leads to an over-emphasis on the role of alcohol in crashes. In any case, the techniques and procedures that have been pioneered by those interested in the

BAC of drivers but not in crashes are applicable to other areas of driver behavior. This technique should be applied to other observable behaviors such as speeding, tailgating and such driver infractions as may enter into crash causation.

ROAD SIDE SURVEYS

Paul Hurst (3) has reanalyzed the data from the majority of roadside survey studies and compared the resulting BAC risk curves. Each of the studies, occurring in different areas and covering different types and numbers of crashes, produced roughly similar risk curves. His analysis showed little rise in relative hazard up to a BAC of .06%. Beyond this point there is an increasingly accelerated rate of rise, with the relative hazard being between 6 and 7 times as great as normal at a BAC of .10%. The curves attempt to express the relationship between one piece of driver behavior, the BAC, and the probability of being involved in a crash. This relationship provides the best evidence that alcohol plays a causal role in crashes. Such evidence is strengthened if we consider the curves for drivers deemed to be *responsible* for crashes as compared to the curve of *innocent*, non-responsible drivers: the former shows that the risk rate rises rapidly above a BAC of .06%, whereas the latter (Grand Rapid Study) does not show a similar rise.

While roadside survey programs were primarily initiated by the governments concerned with the needs of their own safety programs, a major effort has been initiated under a traffic safety study sponsored by the NATO Committee for the Challenges of a Modern Society, to develop standardized protocols for roadside surveys in order to permit comparison of results between nations. This effort has been led by the Canadian Government and has resulted in the adoption of a minimum set of standardized procedures for such surveys. In 1973 both the United States and Canada began national roadside surveys using these standardized procedures.

Under the sponsorship of the U.S. Department of Transportation a file of roadside survey data is being developed at the Highway Safety Research Institute (HSRI) at the University of Michigan. This file consists of two elements, data on 3,358 drivers interviewed in the course of the national roadside survey conducted during the late fall of 1973 (see Wolfe, this volume) and over thirty-five thousand records from 28 Alcohol Safety Action Project sites. These surveys, which are repeated annually at each site, are used as one measure of the impact of the safety projects. The majority of the descriptive data presented below is taken from this file.

Roadside Survey Procedures

Regarding the roadside survey technique itself, those who may be interested in collecting accurate and valid data have a number of excellent sources available to them which describe survey procedures in detail. The Grand Rapids study, which has become a model for roadside survey procedures, has in its original report, considerable detail on the procedures used to collect breath test data (1). In addition, under the sponsorship of the U.S. Department of Transportation, a manual on roadside survey procedures has been developed by Perrine of the University of Vermont (5). Another excellent source for roadside survey procedures is the Canadian Ministry of Transport publication authored by Carl Stroh, which in addition to summarizing the history of research roadside surveys, describes the procedures for standardized international surveys (7). This publication has recently been augmented by the development of a specific working manual on international roadside survey procedures by the National Safety Council. This document, developed under the direction of Robert Borkenstein, and funded by the Department of Transportation, is currently in press.

As with all research, the essential first step in the development of a roadside survey project is a careful determination of the objectives of the survey. Two basic sampling systems have been employed in roadside surveys today. For those research surveys primarily concerned with comparison data on crash-involved drivers, the emphasis has been placed upon sampling a random set of drivers at times and places where the crashes of interest occurred. Perhaps the best example of this type of sampling is illustrated in the Perrine and Waller study in Vermont (6). The researchers first chose a set of fatal and serious injury crashes for which BACs and other driver data were obtainable. A control or comparison sample of non-crash involved drivers was then drawn using the actual sites where these crashes had occurred. Each site was visited on the same day of the week at the same hour of the day as the corresponding crash had occurred. A survey site as close geographically to the corresponding crash site as could safely be managed was chosen. They then sampled from the traffic stream those vehicles moving in the same direction on the roadway as the responsible driver in the crash. In this way, they attempted to sample the exposed population corresponding to the particular group of fatal and serious accidents in which they were interested.

A second type of sampling approach has been selected for the International Survey Program. This random geographical technique is illustrated in the present volume in the paper by Bernard Fox and Robert Borkenstein. In this procedure a grid is laid over a map of the area to be sampled and small segments are selected by use of random numbers so that each unit area has an equal opportunity to be selected in the sample. Here one is not concerned with the frequency of alcohol in the population most exposed to a certain type of crash but rather with the average level of alcohol in all drivers using the road within the given regions.

The procedure for developing a random sample of an area as large as the U.S. or Canada is an especially difficult task. Through the years, opinion polling techniques based on visits to selected households has been developed to a fine art. Corresponding techniques for sampling moving vehicles have not been developed. To support the International Program for Roadside Surveys, both the Canadian and U.S. Governments have been struggling to find a suitable sampling system. The U.S. efforts to conduct a national roadside breath test survey is described in the present proceedings by Arthur Wolfe.

In these surveys the length of the interview is highly dependent upon the nature of the information desired. The breath test itself can usually be conducted within a minute. If necessary, it can be taken while the driver is still in his own car, in a matter of a few seconds. In some surveys the full interview is conducted with the driver remaining in his own vehicle. In this case the breath test is usually taken by a portable device such as the crimper system. This device permits the preservation of a breath sample for later analysis. More elaborate systems in which the driver is invited out from behind the wheel of his car and into a van have generally been used in U.S. surveys. Each approach has certain advantages and disadvantages. If the driver is left in his own vehicle, he may be less patient and more anxious to get away and the breath sample itself could be affected if the temperature is quite cold. It may also be difficult for interviewers if there is inclement weather. On the other hand, if the better environment of a van or a trailer is used, one may run the risk that the driver will refuse to leave his vehicle and thereby part or all of the interview will be lost.

Validity of Survey Results

There are two factors which can greatly affect the validity of the results of the survey. One is the sampling procedures used to select survey sites and the second is the completeness with which all drivers stopped are interviewed and tested. Since high BACs occur in a relatively small proportion of the population, refusals can have a significant effect upon the results. Some indication of the amount of this effect has been illustrated by one of the surveys conducted at the USDOT Alcohol Safety Action Project, in Washtenaw County, Michigan. In that study, directed by Lyle Filkins (4) of the Highway Safety Research Institute, the interviewer who first contacted each driver was asked to make an estimate of whether the driver had been drinking. This estimate was to be made in all cases, whether the driver volunteered to be interviewed and tested or not. The study demonstrated that the interviewer's estimates had some validity and these estimates were later used to correct the results for the portion of the sample which refused to cooperate. This study indicated that those who refused to cooperate had higher BACs, on average, than those who did cooperate.

The roadside surveys file at the HSRI shows data taken from several surveys on the breath test of drivers who agreed to a full interview as compared to those drivers who refused the full interview but did give a breath sample before they left the site. The data show that 71 per cent of those who gave a full interview were at 0 or 0.01% BAC, and only six per cent were above .10% BAC. On the other hand, of that small group who refused the interview but gave a sample, only 62 per cent were alcohol free and fully 22 per cent were at .10% BAC or greater. Thus, there is further evidence that those who refused to cooperate are more likely to have higher BACs.

Accuracy of Interview Ratings

If survey results are to be corrected using interviewer ratings it is important to have an indication of the accuracy of their estimates. Estimations taken from ASAP surveys show a two-category judgment by the contact interviewer. A judgment by the contact interviewer that the driver had been drinking does identify a much higher proportion of individuals over the .10% BAC and the smaller proportion of individuals with 0% BAC. However, this judgment is made on only about one out of five drivers and even at that it is wrong 40 per cent of the time. Using the three category judgment, judgment is made in only about one in five cases, with the same level as the successes before. The "had been drinking a lot" category, while used in only two per cent of the cases does seem to detect a large portion of those who are over .10% BAC. It is clear that if the level of alcohol used in the driving population were to be based simply on a brief interview contact, the data would be highly inaccurate. On the other hand, the interviewers do have a certain level of validity in their judgment. It provides a useful corrective for that (hopefully) small portion of drivers who are missed with the breath test.

BAC CORRELATIONS

The ASAP roadside survey file currently being assembled at the University of Michigan will permit the description of BACs in drivers using the road as a function of a number of environmental vehicle and driver centered variables. It is expected that when completed this file will be the largest source of such information currently available.

Several environmental variables are important in showing correlations with driver BAC. Previous studies have shown that the day of the week and the time of day are significant to the BACs observed. For example, the ASAP file shows that there are significantly fewer drivers with 0% BAC in the late night hours and significantly more, generally almost twice as many, at all higher BACs. Day of week also seems to be significant, at least at some ASAP sites, with Friday and Saturday nights showing higher proportions of drinking drivers than weekday nights. The day differential, however, is less pronounced than might be expected.

Relatively few surveys have been conducted in the winter, so the result is uncertain. It appears that the alcohol level during winter is somewhat lower than during the other three seasons of the year. Geographical characteristics such as urban or rural area and the traffic volume do not appear to have a major effect upon the driver BAC.

Correlation of BAC and Vehicle Type

There is some indication that vehicle type may correlate with BAC level. Undoubtedly, there would have been a significant correlation had commercial vehicles not been excluded from the survey. There is some indication that the BACs of individuals in pickup trucks are somewhat less than that of the other vehicles. However, the data are too limited to give any firm conclusions. With the data available, it was not possible to find the relationship between vehicle age or vehicle condition and alcohol. It would be expected from the relationship of socio-economic status and the alcohol use, described below, that both vehicle age and condition should correlate with the amount of alcohol in the blood of the driver. However, the review performed for the purposes of this report did not indicate a relationship.

Driver Behaviour Variables

BAC and origin and/or destination. There is a significant and important relationship between the BAC and the reported origin and/or destination of the trip. This relationship was noted in Carlson's article on the night-time driver which made use of data from the roadside surveys conducted at the Michigan ASAP (2). The proportion of drivers at 0 or .01% BAC and the proportion of drivers at .10% BAC or greater, were a function of the trip origin and trip destination. On the way to any of the places listed, there was a tendency for a larger proportion of the drivers to have no alcohol and a smaller proportion to have an illegal level of .10% or greater. The highest BACs and the fewest 0% BAC drivers are found among the group that is going to or coming from a bar. The relatively large proportion (7%) who are going to work with a high BAC appears to be anomalous. It may simply reflect insufficient data for reliable results. It appears that travel to and from work and recreation is least likely to be associated with high concentrations of alcohol, while travel to and from the home or a friend's home has a somewhat higher probability of being associated with significant BACs in drivers.

BAC and passengers. There is considerable interest in the relationship between the occurrence of passengers in the car and the BACs of drivers. There appears to be no significant relationship between the absence of passengers or the number of passengers and driver's BAC. Unfortunately, our current file does not contain significant amounts of data on the importance of the type or relationship of the passengers to the driver. Waller, in a roadside survey in Vermont, was able to collect such data by interviewing the passengers (6). This study showed a relationship between the type of passenger and driver BAC. If there were children in the car, as might be expected, it was more likely that the drivers would not be using alcohol.

BAC and age. Moving on to the specific characteristics of the driver, the most significant correlation between a driver characteristic and the use of alcohol is driver age. Teenage drivers are more likely to have no alcohol and far less likely to have an illegal concentration of alcohol than are drivers aged 21 through 55. Elderly drivers, particularly 65 and above, are also less likely to have high levels of alcohol and more likely not to have been drinking.

BAC and sex. The relationship is not as strong as might be expected. Males are less likely to be alcohol free and more likely to be over the illegal limit. This difference, however, may not be of major significance for crash involvement, since women tend to drink less and to be lighter in weight. A lower BAC may have as much significance for them as a somewhat higher BAC would have for the male.

BAC and ethnic group. From the data available in the survey file ethnic group does not appear to have a strong relationship to driver BAC. However, results here are reviewed with caution because some groups were represented by relatively small numbers of individuals.

BAC and marital status. Marital status has been found in a number of studies of crash-involved drivers to be correlated with the probability of the accident involvement. Divorced or separated individuals appear to have a somewhat lower probability of being alcohol free and a significantly higher probability of being at an illegal BAC. It is perhaps surprising that the single or never married show the largest proportion of alcohol free drivers and the smallest proportion of illegally intoxicated drivers. This may be a correlate of age, however: the majority of the single, never married drivers are young and therefore less likely to have developed heavy drinking.

BAC and socio-economic level. Socio-economic levels are an important correlate of crash involvement. They seem to have a small relationship to drinking and driving. ASAP data show little indication that level of education is of any great significance. On the other hand, the job status does appear to be important, particularly if the individual is laid off, unemployed, retired or disabled. The housewife and student categories are contaminated by sex and age correlations with BAC but are consistent with the data mentioned above. A comparison of white collar and blue collar drivers gives some indication that the white collar group has a larger portion of alcohol-free drivers and a lower proportion of intoxicated drivers. Income also appears to have some slight relationship to the probability of alcohol involvement. Our data show that while the number of alcohol-free drivers is generally about the same for persons with incomes under twenty thousand, the proportion of drivers at illegal BACs is highest with the lowest income and fall as the income rises. Taken together, there is some slight evidence that low income, lower socio-economic status groups are more likely to be on the road at significant BACs, and are less likely to be alcohol free, than upper socio-economic status groups.

BAC and drivers' self reports. Another item of special interest is the accuracy with which the driver himself categorizes his drinking behavior. While it is not possible to validate his statement directly, an indirect measure is given by the relationship between his estimate and the BAC obtained in the survey. There is, however, a high, if not perfect relationship. As would be expected, nearly all who claimed to be abstainers do test negatively. The proportion of alcohol-free drivers falls as one moves up the scale from very light to heavy drinkers, while the proportion of drivers at illegal levels shows a corresponding increase. The individuals who classify themselves as heavy drinkers are particularly interesting in that half of these were at an illegal BAC level at the time they were interviewed. It is not clear whether drunkards are more truthful than the general population as regards their drinking behavior or whether alcohol simply reduces the inhibition against admitting to having used alcohol.

BAC and other safety data. Of special interest to the safety community is the relationship of BAC to other safety data. An important question is "do drinking drivers use their safety devices more or less frequently than alcohol free drivers?" When the BACs of drivers who were using and were not using safety belts as reported by the survey team are compared, it is found that there is no apparent difference between the two groups for these data even though some studies have reported reduced usage by drinking drivers. It is perhaps of interest to note that 80 per cent of the drivers interviewed were not using safety belts or safety belts were unavailable as compared to only 12 per cent who used safety belts.

Another issue of interest is the relationship between BAC and traffic accident records. Individuals with no accidents in the previous three years were more likely to be using alcohol. This, at first, seems anomalous. Why do drivers with no accidents on their records have higher BACs than those with one or two accidents? A possible hypothesis for this effect is the correlation of BAC with age. Young drivers are more likely to have offenses and crashes; whereas, the older drivers who use alcohol more are likely to have a higher BAC, and have fewer accidents on their records.

USE OF ROADSIDE SURVEY TO EVALUATE ALCOHOL SAFETY PROGRAMS

The basic criteria for the effectiveness of the highway safety programs are crashes. However, crashes are, as already noted, such complex events, that they respond to many factors including economic and weather conditions. It is probable that one of the reasons so few programs have been validated by scientific evaluation methods is that they have attempted to use the criteria of total crashes, when the project itself was directed at only a segment of the crash problem. Alcohol programs can, in theory, be expected to have an impact on alcohol related crashes, not all crashes. While there is some controversy about the extent to which alcohol plays a role in crashes, it is clear that it is most significant in the relatively limited number of fatal crashes, and that its importance in crash causation is relatively less for less severe accidents. In attempting to evaluate the Alcohol Safety Action Projects in the United States, a number of potential measures of effectiveness have been studied. The best would be the BACs of drivers in crashes. Unfortunately, these are generally available only for fatally injured drivers and then only on a portion of such drivers. Thus, the data are too limited to be very useful for project evaluation. Moreover, the project itself may influence the quality of the collection of these data by placing more emphasis on the collection of blood samples from the drivers.

A larger data base can be obtained by using police estimates of alcohol involvement as reported on accident investigation forms. However, once again, these are suspect in an alcohol safety program since the training and/or the motivation of the police in regard to drinking and driving infractions may be changed directly by the program itself, resulting in a different sensitivity to alcohol involvement and as a result, in a serious increase in the recording of alcohol in accident investigations. To avoid these sources of contamination, primary reliance in the ASAPs for evaluation has been placed on the use of time of day as a 'proxy' measure for the crash criteria. Since most alcohol use occurs at night-time, most alcohol-related crashes also occur at night-time. By studying changes in night as compared to daytime crashes, it is possible to have a relatively clear measure of the criteria of alcohol related crashes. Clearly, however, this criterion includes accidents which are not alcohol related and is at best a proxy measure.

Another measure can be provided by a roadside survey. This is a direct measure of the level of alcohol in drivers using the road. Changes in the percentage of drivers with alcohol and in the average BAC of these drivers should be reflected in the number of alcohol-related crashes. The relationship is not direct or absolute since it is possible that a safety program might remove from the road those drinking drivers who, for whatever reason, have a lower probability of being in a crash, and leave the drinking driver for whom alcohol produces a significantly greater risk of a crash.

Chain of Action through which ASAPs are being Evaluated

The project action begins with the provision of funds for man-hours, equipment and training programs. These in turn produce an activity level in such things as arrests or drivers going through the training program, which in turn should result in the reduction of the number of drivers with high BACs on the road. The final result should be in a change in alcohol-related crashes. The reduction of the BACs of drivers using the road can be conceived as a logical step on the way to achieving reduction in crashes. It also may be more objectively measured than the crash criterion itself.

At the time of the 1973 summary report on ASAPs, 19 of the 35 projects had conducted two roadside surveys, a baseline survey prior to the initiation of the countermeasure program and a second survey generally a year after the initiation of operations. Data for these 19 sites were summarized. In the second survey for the drivers in all three categories (those between .05 and .09% BAC, those between .10 and .14% and those at or above .15%), there was a slight but significant reduction in the proportion of drivers. These differences were tested by χ^2, both on the basis of direct pooling of the data and on the basis of weighing the data so that each project contributed equally to the overall result. In both cases, the second survey was found to be significantly below the baseline survey.

Canadian Evaluation

A similar evaluation was initiated in Canada in connection with the Edmonton safety campaign (Farmer, this volume). In that study, there was an increase in the number of alcohol-free drivers in the experimental cities from the pre-campaign survey to the post-campaign survey, and a corresponding drop in the illegally intoxicated drivers between the pre- and post-campaign survey. This change was statistically significant. However, a change which was not statistically significant but was in the same direction occurred in the control city of Calgary. Thus, it is possible that the reduction in the number of drinking drivers observed is a normal seasonal variation from the November/December period to January. This study, however, provides another interesting example of the uses of roadside survey techniques to evaluate program effectiveness. It is to be hoped that the number of such studies will increase in the future and that this technique will prove to be a useful method for project evaluation.

ROADSIDE SURVEYS OF DRUG USERS

The final topic I will cover here is the initial effort to conduct a roadside survey of drug users among non-crash-involved drivers. The first attempt at such a study was sponsored in 1974 by the U.S. Department of Transportation. In this study a total of just under 1,500 drivers was stopped at two locations in Nebraska and Florida. The survey was set up to obtain interviews regarding driving, drinking and drug use habits of the motorists. Breath tests for alcohol and urine and blood samples for analysis of drug content were also obtained. Finally, a lip swab was used in an effort to detect marihuana use. Because of the desire to collect urine, only males were included in the survey.

Only 78 per cent of those stopped consented to interviews. However, of those who did consent to the interview, nearly all consented to the urine and blood tests. In the case of the blood test, there was a somewhat lower volunteer rate. Some of those who consented to a urine test could not produce urine on the spot. It is interesting that some of these individuals returned with a urine sample after leaving the site. The data loss rate on this survey is too large to permit confidence in the results of the survey itself. But it was useful in demonstrating a surprising level of driver cooperation in a volunteer survey.

This survey was a pilot study for a more complete and highly controlled effort. We are currently attempting to find a location which will permit a roadside survey for drugs and provide comprehensive drug tests on all fatally injured drivers. By putting roadside survey data for drugs together with the data from fatally injured drivers, it should be possible to create dose response curves for drugs similar to those for alcohol. Because of the relatively incomplete data in this survey of drug use, we cannot place great confidence in the following results. Of those who consented to be measured, two-and-a-half per cent of the drivers showed significant amounts of at least one of the drugs for which the samples were analyzed. Two per cent more showed trace quantities of these drugs. In addition, six per cent of the lip swabs were positive for marihuana.

CONCLUSION

These are at best tentative indications of the impact of ASAP and other projects. In the USA, more reliance can be placed on alcohol studies (if not drug studies) once the current data system being developed at the University of Michigan permits the comparison of data for two operational surveys with the original baseline value for these ASAPs. The relatively small changes observed suggest that a larger number of cases are going to be necessary in order to detect the small shifts which these programs are producing. This is the first step in an attempt to use the survey technique for project impact assessment and we hope to learn from this effort more effective techniques for future evaluation programs.

REFERENCES

1. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., Zylman, R. The Role of the Drinking Driver in Traffic Accidents, *Blutalkohol* Vol. 11 Sup. 1, 1974.
2. Carlson, W. C. Alcohol Usage of the Night-time Driver, *Journal of Safety Research* **4**, 12-25 (1972).

3. Hurst, P. M. Estimating the Effectiveness of Blood Alcohol Limits. In *Alcohol, Drugs and Driving*, M.W. Perrine (Ed.) National Highway Traffic Safety Administration Technical Report, D.O.T. HS-801-096, 1974.

4. Filkins, L. D., Clark, C. D., Rosenblatt, C. A., Carlson, W. L., Kerlan, M. W. and Mason, H. *Alcohol Abuse and Traffic Safety A Study of Fatalities, DWI Offenders, Alcoholics and Court-related Treatment Approaches*. U.S. Department of Transportation, National Highway Safety Bureau, Technical Report, FH-11-6555 and FH-11-7129, 1970.

5. Perrine, M. W. *Methodological Considerations in Conducting and Evaluating Roadside Research Surveys*. National Highway Traffic Safety Administration Technical Report, DOT HS-800-471, 1971.

6. Perrine, M. W., Waller, J. A. and Harris, L. S. *Alcohol and Highway Safety: Behavioural and Medical Aspects*. National Highway Traffic Safety Administration Technical Report, DOT HS-800-599, 1971.

7. Stroh, C. M., *Roadside Surveys of Drinking-Driving Behaviour. A Review of the Literature and a Recommended Methodology*. A report prepared for the OECD Initiated Group of Experts on the Effects of Alcohol and other Drugs on Driver Behaviour. Information Canada, 1974.

Drinking and Driving in the Netherlands over a Four-Year Period

P. C. Noordzij[1]

The Institute for Road Safety in Holland (SWOV) has carried out three roadside surveys into drinking habits: one in 1970, one in 1971 and the most recent in 1973. The main purpose was to acquire knowledge concerning the degree and pattern of alcohol usage by motorists prior to the introduction of a legally prescribed blood alcohol concentration (BAC) limit. The trends revealed in these surveys will be taken into account in determining the effect of the new legislation which is to be introduced in November 1974.

This paper will describe the present trends and attempt to uncover those variables showing a clear relation to motorists' alcohol usage.

DESIGN OF ROADSIDE SURVEYS

In order to obtain a representative national sample of drivers, 30 municipalities were selected with a proportional representation of rural and urban areas. Within each municipality three survey sites were selected in the centre and on the outskirts. Although the final sample had some shortcomings, these did not affect comparisons between the various years.

Each survey site was visited once during the survey year by one of the research teams. During the course of the survey, one site in each municipality was selected randomly for Friday, Saturday and Sunday surveys. No municipality was used more than once during a weekend.

The survey took place over ten successive weekends in September, October and November of each survey year. Three research teams were used, each at a different survey site, for the three weekend nights, from 10 p.m. to 4 a.m.

The survey was limited to passenger car drivers. At approximately every ten minutes a car was directed to a member of the team. He explained the nature of the survey briefly, and asked for the driver's cooperation. If the driver agreed, he was given a ten-minute interview and asked to provide a blood sample and take two breath tests. Personal information was guaranteed to be kept strictly confidential.

If the driver refused to cooperate, the researcher noted some information. If it became apparent that a driver was too intoxicated to drive, he was offered the use of a taxi.

---

[1] Research Psychologist, Institute for Road Safety Research SWOV, Voorburg, The Netherlands.

EXECUTION OF THE PROGRAMME

In 1970, 3,141 motorists were asked for their cooperation; out of these, 451 (14%) refused. In 1971, 3,417 were asked and 434 (13%) refused. In 1973, of the 2,617 asked, 483 (18%) refused.

Although the three surveys corresponded on the main points, modifications were introduced into some of them. For instance, due to road reconstruction, some of the survey sites had to be changed. The new site was matched as closely as possible for comparable traffic passing through it. In some places the questionnaire was altered as a result of experience. And finally, different breath analysing devices were used in the successive surveys, since a secondary aim of the invesigation was to find a breath analysing device suitable for use in such surveys in place of the blood test. In 1970, a PYE-gas chromatograph was used in the blood analysis; this was replaced in the next two surveys by a Perkin Elmer. The equipment for taking and storing the blood samples was also modified.

Whenever possible, the driver's blood test was used; when this was unavailable, an estimation of the BAC was made on the basis of the breath test. In 1973, relatively greater use was made of breath tests due to faults in the blood sample analysis. (A comparison of the breath and blood analyses is reported in Section 3 of these Proceedings.)

Because of the blood analysis failure in 1973, the lower limit for deciding whether or not alcohol had been consumed was set at a relatively high level (20 mg/100 ml) in order to be certain that a measured BAC below 20 mg/100 ml really was below this figure. For the sake of comparison, the same limit was used for 1970 and 1971.

In 1973 the survey was cut short after the seventh weekend because driving on Sunday was prohibited as a result of the oil crisis. Sunday driving overlapped the times of the roadside survey. However, results of the previous surveys allowed us to assume that the results of the first seven weekends were representative of the full period of ten weeks.

As mentioned above, the percentage of refusals in 1973 was higher than in the previous two surveys. In none of the three years, however, were there any indications that use of alcohol by those who refused the tests differed from the use of the drivers who cooperated.

RESULTS

Analysis of the results was carried out in two phases, firstly by a multivariate analysis and then by simpler analyses of selected variables. Only the results of the simpler analyses are presented here.

The relationships between such variables as sex, age, place of drinking, time of drinking, and the BAC distribution of the motorists is described. These are made on a basis of the combined data for the three years. Subsequently a comparison is made between the 1970, 1971 and 1973 surveys. The data are weighted on a basis of the ratio of the number of persons interviewed to the number of passing cars through each survey site for every two hour period. The BAC is classified into four groups: 00-20; 20-50; 50-100 and 100 mg/100 ml and above. For the sake of convenience the terms alcohol usage, drinking and BAC will be used to mean the same as the distribution of BAC groups.

Sex. The personal variable which was found to have the most striking relation to the BAC was the sex of the driver. Men were found to have drunk far more than women, although some women had BACs above 100 mg/100 ml. (Table I, Figure 1).

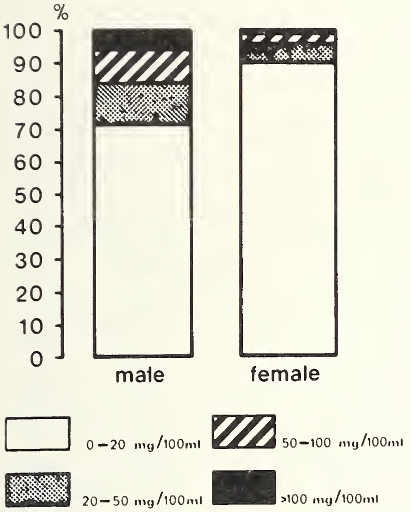


Figure 1 *BAC distribution by sex*

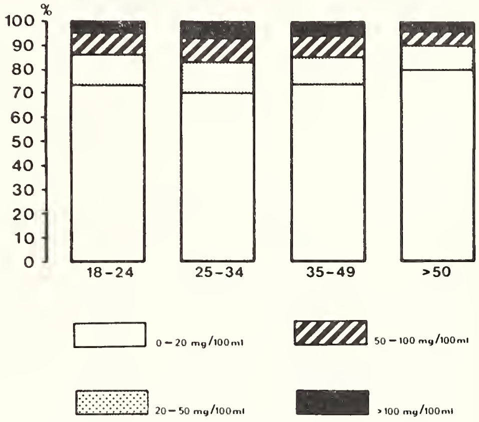


Figure 2 *BAC distribution by age*

Age. Drivers in the 25-53 year age group drank slightly more than those in the younger and older groups (Table II, Figure 2). This contradicts a fairly prevalent belief that it is mainly young drivers who drink most heavily. This belief can be partly explained by the fact that a great proportion of drivers on the road on weekend evenings are young. We found that nearly one third of the drivers with a BAC above 100 mg/100 ml were under 25 and another third between 25 and 35 years of age.

TABLE I *BAC Distribution by Sex (1970, 1971 and 1973)*

	% drivers with BAC of:				
Sex	0-20	20-50	50-100 mg/100 ml	>100	Σ0->100
male	71	13	10	6	100
female	90	6	3	1	100
total	73	12	9	6	100

Place of drinking. Among those drivers coming from a pub or bar, alcohol usage increased strongly with age, up to the age of 50. More striking than relationship between age and BAC of drivers coming from a pub or bar was the high level of alcohol use of this group in comparison to all drivers (Table II, Figure 3). This was demonstrated by the fact that about 20 per cent of all drivers came from a pub or bar; but when drivers with a BAC of above 100 mg/100 ml were examined it was found that between 40 and 50 per cent had come from pub or bar.

TABLE II *BAC Distribution by Age for all Drivers (1970, 1971 and 1973)*

Age	% drivers with BAC of: 0-20		20-50		50-100 mg/100 ml		>100		Σ0->100 for each group
	total	pub or bar	total	pub or bar	total	pub or bar	total	pub or bar	
<25 years	73	56	13	19	9	15	5	10	100
25-35 years	70	43	13	22	10	18	7	17	100
35-50 years	74	37	11	24	9	20	6	19	100
>50 years	80	59	10	18	6	14	4	10	100
Total	73	50	12	20	9	17	6	13	100

Time. The time of night had some influence on the relationship between age and BAC. The age group 25-35 years with higher BACs was more prominent in the hours of 2 a.m. to 4 a.m. In comparison with other age groups, drivers of 50 years of age and over tended to be less moderate (Table III). That is, in both the 25-35, and the 50 plus age groups the intake of alcohol increased in the course of the evening somewhat more steeply than for the other age groups. However, the differences were small in relation to the total effect of time on BAC distribution (Table III, Figure 4).

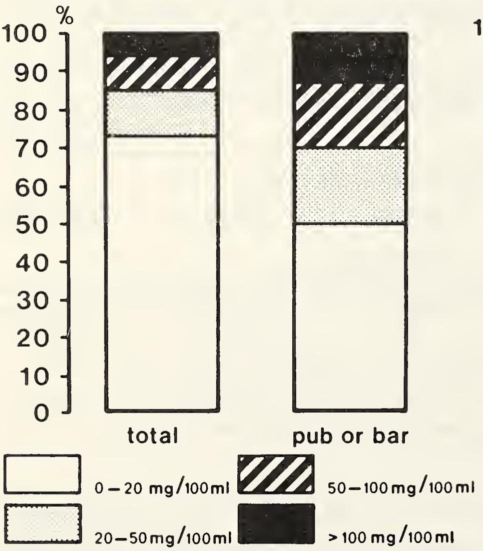


Figure 3 *BAC distribution for all drivers and for drivers coming from pub or bar only*

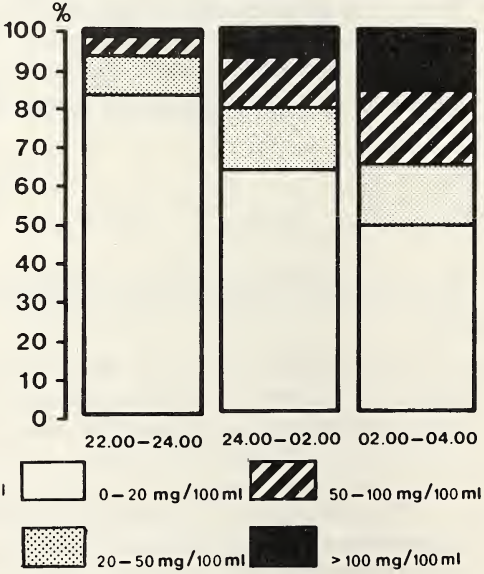


Figure 4 *BAC distribution by time*

TABLE III *BAC Distribution by Age and Time of Day (1970, 1971 and 1973)*

			% drivers with BAC of:		
Age	0.20	20-50	50-100	>100	Σ0->100
			mg 100/ml		
22.00 - 0.00 pm					
<25 years	82	10	6	2	100
25-35 years	83	10	4	3	100
35-50 years	83	9	5	3	100
>50 years	85	9	4	2	100
AVERAGE	83	10	5	3	100
0.00 - 02.00 am					
<25 years	62	17	13	9	100
25-35 years	60	16	15	9	100
35-50 years	64	15	13	9	100
>50 years	73	13	9	5	100
AVERAGE	63	16	13	8	100
02.00 - 04.00 am					
<25 years	56	15	16	13	100
25-35 years	42	17	21	20	100
35-50 years	50	16	20	15	100
>50 years	52	20	16	12	100
AVERAGE	49	16	19	16	100

Between 10 p.m. and midnight only a few drivers had a BAC above 100 mg/100 ml. Between 2 and 4 a.m. this figure increased to between 15 and 20 per cent. On the other hand, in actual numbers, there was hardly any increase in drivers with a BAC above 100 mg/100 ml. between 2 and 4 a.m. compared to between 10 p.m. and midnight.

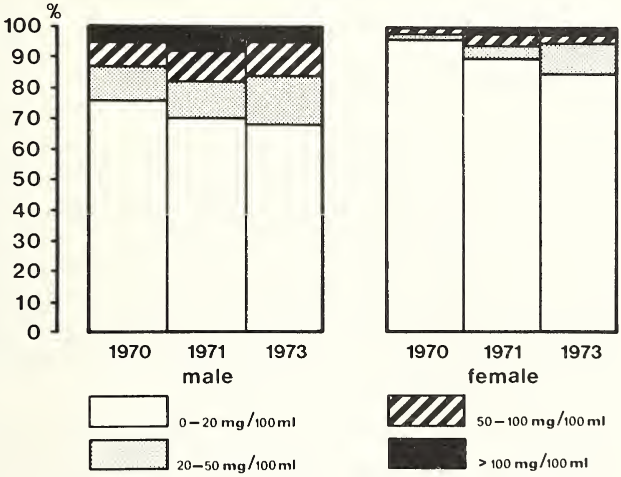


Figure 5 *BAC distribution by year and sex*

TABLE IV *BAC Distribution by Year: Male Drivers only*

Age	% males with BAC of: 0-20	20-50	50-100 mg/100 ml	>100	Σ0->100
1970					
<25 years	78	10	8	4	100
25-35 years	75	12	7	6	100
35-50 years	72	12	10	6	100
>50 years	79	8	7	6	100
AVERAGE	76	11	8	5	100
1971					
<25 years	68	14	10	8	100
25-35 years	65	12	13	10	100
35-50 years	74	11	8	7	100
>50 years	81	10	6	4	100
AVERAGE	70	12	10	8	100
1973					
<25 years	66	17	12	5	100
25-35 years	63	19	13	6	100
35-50 years	70	13	11	6	100
>50 years	78	15	6	1	100
AVERAGE	68	16	11	5	100

Over the four-year period during which the three surveys were conducted, a slight increase in drinking among deivers was noticeable (Tables IV and V, Figure 5), for both men and women. Among men this increase at first seemed to be restricted to drivers below 35 years of age (compare 1971 to 1970) but later it applied to all age groups. For women, the opposite held. The year 1971 showed an increase over 1970 for all age groups, whereas comparison of 1973 to 1971 and 1970 showed an increase only among women drivers under 35 years of age. In addition, it should be noted that 1971 constituted an exception with regard to BACs above 100 mg/100 ml: they were more frequent that year that in the other two years.

This increase in drinking over the four years can largely be accounted for by the increase in drinking by drivers coming from pub or bar (Table VI). The 1971 figures for BACs above 100 mg/100 ml were an exception for this group as well.

TABLE V *BAC Distribution by Year: Female Drivers only*

Age	0-20	20-50	% females with BAC of: 50-100 mg/100 ml	>100	Σ0->100
1970					
<25 years	96	1	3	–	100
25-35 years	94	4	2	–	100
35-50 years	96	2	2	–	100
>50 years	100	–	–	–	100
AVERAGE	96	2	2	–	100
1971					
<25 years	87	6	4	4	100
25-35 years	90	3	6	1	100
35-50 years	94	2	3	2	100
>50 years	94	6	–	–	100
AVERAGE	90	4	4	2	100
1973					
<25 years	80	19	1	1	100
25-35 years	80	9	5	7	100
35-50 years	92	3	4	2	100
>50 years	95	5	–	–	100
AVERAGE	85	10	3	3	100

TABLE VI *BAC Distribution by Year for all Drivers and for Drivers Coming from Pub or Bar only*

Year	0-20	20-50	% drivers with BAC of: 50-100 mg/100 ml	>100	Σ0->100
Total					
1970	78	10	8	5	100
1971	72	12	9	8	100
1973	69	16	10	5	100
pub or bar					
1970	60	18	14	9	100
1971	47	18	18	18	100
1973	40	28	18	14	100

SUMMARY OF RESULTS

At weekend nights women motorists drank less than men. Drinking increased rapidly from early to late at night. Alcohol use of drivers increased over the years for both men and women and both early and late at night, but particularly for drivers coming from pub or bar. In this sample, alcohol consumption increased rapidly with age up to about 50 years. However, younger drivers comprised the larger part of motorists coming from pub or bar. The general relation for age and BAC was found to be slightly U-shaped with the 25-35 year group scoring highest late at night.

Characteristics of Late-Night, Weekend Drivers: Results of the U.S. National Roadside Breath-testing Survey and Several Local Surveys

Arthur C. Wolfe[1]

In the Fall of 1973 the Highway Safety Research Institute (HSRI) of the University of Michigan conducted the first nationwide roadside breathtesting survey in the United States. This paper will discuss some of the methodological problems involved in such a massive effort and will present some of the substantive findings of the survey[2].

SURVEY DESIGN AND PROCEDURES

At the outset it was decided to conduct this national survey in the United States (excluding Alaska and Hawaii) and only on Friday and Saturday nights between the hours of 10:00 p.m. and 3:00 a.m. This decision was due to financial constraints and the desire to collect as many cases as possible during the periods which previous research had shown to contain the largest proportion of drunk drivers. These periods also conformed to the 'core' time for national roadside surveys recommended by the Subgroup on Roadside Surveys of the OECD-Initiated Group of Experts on the Effects of Alcohol and Other Drugs on Driver Behavior.

The basic goal of the survey was to obtain reliable estimates of the extent of driving at various levels of alcohol impairment for the United States as a whole. These findings are to provide a baseline for the measurement of progress in reducing the incidence of impaired driving and for the analysis of the results of various local roadside breathtesting surveys.

It should be noted that the survey goal was to estimate the percentages of *driving* at various levels of alcohol impairment. Thus the results could be directly translated into risk statements. If it were found that one tenth of late-night weekend driving was performed by impaired drivers, then one could say that, on the average, a motorist driving during these time periods could expect that one out of ten cars which he met would be operated by an impaired driver. This is not necessarily the same as saying that one out of ten *drivers* during these time periods was drunk. This would depend on the average trip durations of the impaired and nonimpaired drivers. If the impaired and nonimpaired drivers tended to be on the road for similar lengths of time during the relevant time periods, then the percentage of impaired *driving* and impaired *drivers* would be about the same. However, if, for example, the average impaired driver was on the road only half as long as the average nonimpaired driver, then one could say that 10% of the *driving* was done by impaired drivers but that 18.2% of all the *drivers* during these periods were impaired. In actual fact the national survey found nonimpaired drivers averaged only slightly longer trips than impaired drivers, so it was not necessary to worry about this distinction. However, it should not be assumed that percentage of impaired *driving* and percentage of impaired *drivers* are necessarily the same thing.

---

[1] Highway Safety Research Institute, University of Michigan, Ann Arbor, Mich, 48105, U.S.A.

[2] A more complete report on this survey entitled *1973 U.S. National Roadside Breathtesting Survey: Procedures and Results* by Arthur C. Wolfe is available from the Highway Safety Research Institute or from the National Technical Information Service, Springfield, Va. 22151.

In developing a sampling design for a national survey of this sort there were many practical considerations which had to be faced. The ideal simple random sample design would involve some mechanism – perhaps a flying saucer perched in the sky ready to pounce on an unsuspecting motorist – to select one driver at random from the millions of drivers on American roads at any given minute. However, this is obviously a practical impossibility. Instead, some controlled probability scheme had to be devised to select a limited number of roadside locations at which the survey crews would stay for a certain period of time. At these sites they would then randomly select particular vehicles from the passing traffic stream to participate in the survey. Fortunately, this design works satisfactorily to provide estimates based on driving time. The longer a particular motorist is on the road the greater the likelihood that he will chance upon a roadside survey site. However, it is also true that the faster he drives the more likely he is to pass a survey site, and that the lighter the traffic flow the more likely he is to be selected at that site, so weighting factors for average speed and traffic volume had to be included in the sample design.

Besides the geographic and time restrictions mentioned above, there were some other logistical considerations which had to be taken into account in establishing the geographic universe to be sampled. For the efficiency of the survey operation it was important that chosen roadside locations have sufficient nighttime traffic volume to keep the interviewers relatively busy throughout the survey period. Thus it was decided to exclude counties under 20,000 in population from the survey universe. This excluded a large proportion of the area of the United States from the universe of potential roadside locations, but these counties contained only 8.1% of the population. In the remaining counties only roads estimated to have a traffic volume of at least 10 cars per hour in the 2-3 a.m. period or 2,000 average daily traffic volume (ADT) were included. Also, due to safety considerations in operating the roadside interviewing stations, it was necessary to exclude freeways and other roadways lacking safe adjacent pull-off areas.

A further practical consideration in choosing roadside locations was the fact that it was necessary to obtain the assistance of local police officials in conducting the survey. In contrast with a typical household survey in which an interviewer is free to go knocking on people's doors without any official assistance or approval, it was felt that in a roadside survey police officers were needed to assist in traffic control and in the motorist selection process – particularly since the survey operations would be at night when visibility problems might be serious. However, participation in the survey was to be voluntary. In very few, if any, jurisdictions in the United States is it legal for the police to establish random roadblocks and to require motorists who have been stopped to provide a breath sample. Therefore, the desired role of the police was to flag down the first approaching vehicle when it was requested by the interviewer and to send the selected vehicle into the parking area where the interviewer explained the survey and asked the motorist to cooperate by parking and coming into the survey vehicle.

A further complication was the fact that in the United States there is no national police force whose assistance could be counted on everywhere. In fact, local police tend to be rather jealous of their jurisdictional boundaries, and it was found that state and county police departments were generally unwilling to provide assistance within communities which had their own police forces. So in each locality selected for the survey operation it was necessary to obtain not only the approval of local police officials but also their willingness to assign two to four police officers to the survey crews. Even though payment was available for such police services, there were a number of police jurisdictions in which the necessary cooperation was not forthcoming, and different localities had to be substituted in the sample design. There were also three police jurisdictions in which the police were willing to cooperate although they would not participate directly in the random stopping. In those areas police officers were present, but survey personnel had to flag down the vehicles; and they proved generally less effective at this than experienced police officers.

With this background in mind the sampling plan will be briefly described. It was decided to use three survey crews over a period of eight weekends, thus utilizing 24 basic primary sampling areas (one weekend in each). In order to choose these 24 areas the United States was divided into 12 strata based on four regions and three rural-urban types. These three types were central cities of Standard Metropolitan Statistical Areas (SMSAs) (as defined by the 1970 United States Census), other whole or part counties which are part of SMSAs, and counties over 20,000 in population which are not part of SMSAs. The percentages of the U.S. population in the four major regions and in these rural-urban types are shown in Table I. Table I also shows the number of primary selections which ideally would have been made in each of the 12 basic strata to give a total of 24 primary selections, and it shows the number of actual substrata used within each strata.

TABLE 1 *Number of Selections per Stratum*[a].

	SMSA Central Cities	(31.4%)	Other SMSA Parts	(37.3%)	Non SMSA Counties	(31.3%)	Total	(100.0%)
Region	Ideal	Actual	Ideal	Actual	Ideal	Actual	Ideal	Actual
North East (26.4%)	2.23	2	2.85	3	1.25	1	6.32	6
North Central (27.3%)	2.21	2	2.67	3	1.67	2	6.55	7
South (29.3%)	2.32	3	2.25	2	2.47	2	7.03	7
West (17.1%)	1.45	1	2.01	2	0.63	1	4.09	4
Total (100.0%)	8.22	8	9.75	10	6.02	6	23.99	24

[a] Choosing 24 Substrata from 12 Strata composed of the SMSA Central Cities and the Counties of the contiguous United States (excluding counties under 20,000 in population), based on 1970 census populations

Total Estimated Population = 185,293,000
Average Size Per Substratum = 7,721,000

It should be mentioned that although ideally the selections of primary sampling areas are based on the varying extents of late-night weekend driving in the different geographic areas, such information is simply not available in most geographic areas. In fact even driving-related data such as numbers of licensed drivers or registered vehicles or gallons of gasoline sold are not readily available for most localities. Therefore, population data seemed to provide the only practical base for selecting the primary sampling areas. While it is recognized that there may not always be a direct one-to-one relationship between an area's population and the amount of late-night driving on weekends within its geographic confines, in general the correlation between these two variables should be quite high. It is hoped that no serious bias was introduced by using this data base.

So the first step of the sampling process involved the listing of all geographic areas in each of the 24 substrata in order, by population size. Then a number of selections were made in each substratum by a table of random numbers whereby each geographic area had a chance of selection directly related to its population size. If a selected geographic area contained only one police jurisdiction, it was contacted directly for police assistance to be provided on both Friday and Saturday nights during one weekend. If the selected area contained more than one police jurisdiction, a further secondary selection was made of up to two police jurisdictions within each primary sampling area in relation to the population size of the available jurisdictions. Each of these jurisdictions was to be used for one night.

In all, 34 different police jurisdictions were initially chosen in the national roadside survey. Twenty-four of these police departments were willing to participate in the national survey, although not without considerable persuasive effort in some cases. For ten jurisdictions substitute police departments were found within the same primary substratum. The police were mainly concerned about a negative public reaction to police cooperation in such a random stopping procedure and about having to place their limited manpower on such duty at a particularly busy time of the week. Some departments were also concerned about the confidential nature of the survey and did not like the idea of letting alcohol-impaired drivers continue on their way. In most jurisdictions local cars and drivers were provided, to offer transportation to impaired motorists, but it was not intended to force motorists to accept such alternate transportation. In actuality many impaired motorists were not willing to accept the proffered ride and drove off themselves after the interview.

Once the cooperation of the relevant police jurisdiction was obtained, four or eight random roadside locations had to be chosen in each jurisdiction, depending on whether the team would be working there one or two nights. The general procedure used involved (a) drawing a grid of half mile squares over the entire jurisdiction, (b) selecting a certain number of squares by random number, (c) determining from local police and traffic engineering sources whether any of the road segments in the selected squares met the traffic volume criteria, and (d) if so, visiting the segment to seek a suitable off-street or road shoulder survey site. In general the intention was to sample traffic in one direction only, but if the traffic volume proved to be lower than expected the survey teams were permitted to sample in both directions, adjusting accordingly the counting of the actual traffic volume past the site.

The basic plan called for two crews to be working simultaneously at two different sites in each jurisdiction, and each crew was to work two different sites each night, one from about 10:00-12:00 p.m. and the second from about 1:00-3:00 a.m. One crew in each jurisdiction contained two interviewers and this crew worked at the heavy volume sites (defined roughly as 30 vehicles per hour in the 2:00-3:00 a.m. period or at least 6000 ADT). The other crew had only one interviewer. It was expected that about 25 interviews would be obtained at each heavy volume site and about 12.5 interviews would be obtained at each medium volume site, or about 150 interviews per weekend in one primary sampling area. This would have provided a total of 3,600 interviews. However, due mainly to low traffic volume problems at some sites the total number of obtained interviews was 3,353 out of the 3,698 vehicles stopped (90.7%). A further 4% of the selected motorists gave an interview but refused to give a breath sample. However, 1.3% of the selected motorists did provide only a breath sample at their cars, so a total of 3,192 breath samples was obtained (88% of the total sample of stopped vehicles).

The breathtesting instrument used at most of the survey sites was the Omicron Intoxilyzer which provided a rapid three-digit blood alcohol concentration (BAC) reading. The Intoximeters Field Crimper was also used extensively at some sites, collecting breath samples in an indium tube for later analysis on a gas chromatograph. In addition, each interviewer had available the pocket-sized Alco-Sensor screening device as a back-up instrument and for use with motorists who would not leave their vehicles. In most areas local Jaycee or other service clubs provided the needed local interviewers and drivers to supplement the two HSRI staff members on each survey team. Due to weather considerations each team started in the northern areas of the United States and moved southward during their eight weeks of operations (from Oct. 26 to Dec. 15). The final schedule dates and locations for the three teams is shown in Table II.

TABLE II *Final Schedule of Regional Survey Teams*

	West Team	*Midwest Team*	*East Team*
October 26	Franklin, Wis.	Buffalo, N.Y.	Oswego County, N.Y.
October 27	Wauwatosa, Wis.	Buffalo, N.Y.	Oswego County, N.Y.
November 2	Duluth, Minn.	Dover and Tuscarawas County, Ohio	Torrington, Conn.
November 3	Duluth, Minn.		Winsted, Conn.
November 9	Sedro-Woolley, Wash.	Columbus, Ohio	Nassau County, N.Y.
November 10	Skagit County, Wash. (Wash. State Patrol)	Columbus, Ohio	Nassau County, N.Y.
November 16	Seattle, Wash.	Williams County, Ohio	Brooklyn, N.Y.
November 17	Seattle, Wash.	Williams County, Ohio	Brooklyn, N.Y.
November 23	Springfield, Ore.	Lapeer, Michigan	Madison, N.J.
November 24	Lane County, Ore.	Lapeer County, Mich.	Randolph, N.J.
November 30	Gilroy, Calif.	Hamilton County, Tenn.	Bristol, Va.
December 1	Palo Alto, Calif.	Hamilton County, Tenn. (Tenn. Highway Patrol)	Washington County, Va.
December 7	New Orleans, La.	(None)	Raleigh, N.C.
December 8	New Orleans, La.		Raleigh, N.C.
December 14	St. Louis County, Mo.	DeKalb County, Ga. and Indianola and Sunflower County, Miss.	Miami, Fla.
December 15	St. Louis County, Mo.		Miami, Fla.

SURVEY RESULTS

The basic results of the survey in terms of BACs are shown in Table III. These are shown for the total sample and for the late evening and early morning time periods separately. Table III also demonstrates that there are only small differences in results when the data are weighted or unweighted. The drinking estimate weights are based on interviewer estimates of the drinking condition of all potential respondents (both refusers and participants) during the initial contact at the roadside. It is gratifying to note that there is no evidence of serious bias in the results from the refusal of 12% of the selected drivers to provide a breath sample.

TABLE III *National Comparison of Percentage of Cases at Various BACs*[a]

		BAC Reading (g/100 ml)					
Time and Weight Factors	N	.00-.01	.02-.04	.05-.07	.08-.09	.10-.14	.15+
10-12 pm	1686						
No Weighting		83.5	7.5	4.4	1.6	2.0	0.9
Speed/Traffic and Population		83.1	7.8	4.7	1.5	2.0	1.0
Speed/Traffic and Population, and Drinking Estimate		82.9	7.7	4.8	1.5	2.1	1.1
1-3 am	1506						
No Weighting		66.7	12.0	8.4	4.7	6.4	1.9
Speed/Traffic and Population		66.0	12.7	8.1	4.6	6.7	1.8
Speed/Traffic and Population, and Drinking Estimate		66.5	12.4	8.0	4.5	6.7	1.9
Total	3192						
No Weighting		75.5	9.6	6.3	3.1	4.1	1.4
Speed/Traffic and Population		77.2	9.4	6.1	2.4	3.5	1.4
Speed/Traffic and Population, and Drinking Estimate		77.4	9.2	6.1	2.4	3.6	1.4

[a] Using unweighted data, data weighted by Speed/Traffic Factors and Population Factors, and data weighted by Speed/Traffic and Population and Drinking Estimate Factors, for total sample and two time periods.

Almost half of the drivers interviewed said that they had drunk alcoholic beverages sometime on the day of the interview (only one out of six claimed to be total abstainers), and 22.6% registered a BAC of 0.02% (g/100 ml) or more. About one eighth of the drivers had been drinking to an extent great enough to impair their driving performance (0.05% BAC or higher), and one out of twenty was at a BAC considered illegal in every state (0.10% or higher). These summary findings are shown in Table IV along with their estimated sampling errors. The sampling error for the sample design utilized in the survey is about one and a half times as large as would be expected in a simple random sample design.

As would be expected, the survey found that the proportion of drinking drivers increased later at night. Table V shows the BAC results by hour of interview. In the 2:00-3:00 a.m. period almost one quarter of the respondents were probably impaired, and one out of nine were at illegal BACs. It is fortunate that traffic densities tended to be quite low at these times of heaviest drinking driver concentration, so accidents were not as numerous as they would be at a busier time of day. However, it should be noted that these drinking drivers were involved in a disproportionate number of single-vehicle accidents during the early morning hours. Table VI presents the BAC results for Friday and Saturday nights separately. The differences are not very great, but they suggest that impaired driving tends to be an even more serious problem on Saturday nights than on Friday nights.

Turning to background characteristics of the drinking drivers, it is not surprising to find that many more males than females drove late on weekend nights and that these male drivers were more likely to be impaired than the females (14.5% compared to 8.4% at 0.05% BAC or higher). In regard to age and impaired driving the survey found the familiar inverted U-shaped relationship. The most extensive drinking was found among drivers aged 25-44 with declining percentages of impaired driving among both younger and older respondents. The survey also found disproportionately high

TABLE IV *National BAC Results, Their Sampling Errors,*[a] *and Estimated Reductions Necessary for a Statistically Significant Change*[b]

	BAC Reading (g/100 ml)			
	.02+	.05+	.10+	.15+
Percentage	22.63	13.46	4.92	1.36
Sampling Error	3.05	2.18	1.06	0.49
Maximum Statistically Significant Reduced Percentage	19.08	10.92	3.69	0.79
Percentage Change Needed for Statistical Significance	16	19	25	42

[a] The sampling error used is two times the standard error; that is, the sampling error based on a 95% confidence level.

[b] Using Speed/Traffic, Population, and Drinking Estimate weights (based on weighted N of 3719).

TABLE V *National Comparison of Percentage of Cases at Various BACs by Time of Night; Using Speed/Traffic, Population, and Drinking Estimate Weights*

	Wtd.	BAC Reading (g/100 ml)					
Time Period of Interview	N	.00-.01	.02-.04	.05-.07	.08-.09	.10-.14	.15+
10-11 pm	1032	85.5	6.4	3.9	1.8	1.5	.09
11-12 pm	1210	81.8	8.4	5.5	1.3	2.0	1.1
12-1 am	133	75.1	12.0	7.5	0.0	3.8	1.6
10-1 Subtotal	1685	82.9	7.7	4.8	1.5	2.1	1.1
1-2 am	573	66.0	12.8	8.9	3.8	5.8	2.6
2-3 am	524	64.3	11.2	8.2	5.3	9.3	1.8
3-4 am	46	75.1	4.2	10.4	4.9	4.4	1.0
1-4 Subtotal	1505	66.5	12.4	8.0	4.5	6.7	1.9
TOTAL	3719	77.4	9.2	6.1	2.4	3.6	1.4

percentages of impaired drivers among blacks, non-high school graduates, divorced and separated persons, and blue collar workers. The BAC results for these background variables are presented in full in Table VII.

Table VIII presents the BAC results in relation to various driving characteristics. The survey found more impaired driving among unaccompanied drivers, among drivers with relatively low annual mileages (under 10,000 miles), and among drivers on relatively short trips. However, none of these differences was very great. In terms of trip purpose it is not surprising to find that persons traveling to or from eating or drinking places were much more likely to be impaired than the other respondents. In particular,

TABLE VI *National Comparison of Percentage of Cases at Various BACs for Friday and Saturday Nights; Using Speed/Traffic, Population, and Drinking Estimate Weights*

Night	Wtd. N	BAC Reading (g/100 ml) .00-.01	.02-.04	.05-.07	.08-.09	.10-.14	.15+
Friday Nights	1972	78.7	8.3	6.4	2.4	3.2	1.1
Saturday Nights	1747	75.9	10.2	5.8	2.4	4.0	1.7

TABLE VII *National Comparison of Percentage of Cases at Various BACs and Demographic Characteristics of the Drivers*

Demographic Characteristics	Wtd. N	BAC Reading (g/100 ml) .00-.01	.02-.04	.05-.07	.08-.09	.10-.14	.15+
Sex							
Male	3101	75.7	9.8	6.4	2.7	3.8	1.6
Female	586	85.1	6.5	4.7	1.1	2.3	0.3
Race							
White	3230	77.9	8.9	5.7	2.5	3.7	1.3
Black	328	72.9	11.9	7.2	2.5	2.7	2.8
Age							
16-17	242	88.4	3.3	3.8	1.7	2.7	0.0
18-20	596	81.5	7.3	5.3	1.7	3.0	1.2
21-24	622	74.6	10.6	6.7	2.9	4.2	1.0
25-34	948	74.1	10.7	6.9	2.2	4.6	1.6
35-44	481	74.6	9.5	6.1	3.9	4.3	1.6
45-54	436	78.6	8.0	6.6	2.4	2.2	2.2
55-64	231	78.2	11.5	4.6	2.6	1.0	2.1
65+	71	85.8	5.0	5.5	1.8	2.0	0.0
Education							
High School Not Finished	956	79.0	6.2	6.4	2.1	4.3	2.0
High School Finished	1257	77.0	10.0	5.6	2.9	3.5	1.2
Some College	873	77.6	8.8	6.3	2.6	3.3	1.4
College Finished	542	74.9	13.0	6.4	2.2	2.7	0.9
Marital Status							
Married	1799	77.8	8.6	5.9	2.6	3.5	1.5
Single	1497	79.8	9.0	4.9	2.2	3.3	0.8
Divorced	222	61.1	15.6	11.0	4.7	4.6	3.0
Separated	69	62.6	11.1	15.3	0.0	7.2	3.9
Widowed	45	69.5	2.0	12.5	0.0	1.1	4.9
Occupation							
Unemployed	180	76.5	13.3	4.3	2.0	3.9	0.0
White Collar	1172	75.7	12.2	5.7	2.4	3.0	0.9
Blue Collar	1732	76.0	8.2	6.9	2.9	4.1	2.0
Farmer	23	82.2	15.8	0.0	0.0	1.9	0.0
Housewife	90	92.9	3.0	2.3	1.2	0.0	0.5
Student	433	84.3	4.8	6.1	1.8	2.9	0.1

more than half of the 105 respondents who said they were going from one eating or drinking place to another eating or drinking place were at or above 0.02% BAC, and more than one third were probably impaired (0.05% BAC or higher). About one sixth of the interviewed motorists said they were traveling to or from work, and even this group contained substantial numbers of drinking drivers. Two per cent of them were at illegal BACs, and 7.7% were at probably impaired BACs.

TABLE VIII *National Comparison of Percentage of Cases at Various BACs and Driving Characteristics of the Drivers*

Driving Characteristics	Wtd. N	BAC Reading (g/100 ml) .00-.01	.02-.04	.05-.07	.08-.09	.10-.14	.15+
Number of Passengers							
None	1186	79.2	8.0	5.3	1.5	4.1	1.9
One	1368	75.9	10.6	5.6	3.3	3.3	1.1
Two or More	917	76.4	8.9	8.0	2.4	2.8	1.4
Annual Mileage							
Under 10,000	820	76.8	8.2	5.8	2.3	4.9	2.1
10,000-20,000	1472	78.3	9.2	5.8	2.3	3.4	0.9
20,000-30,000	622	74.7	11.5	6.2	3.8	3.0	0.8
Over 30,000	578	79.7	7.5	6.5	2.0	2.3	1.9
Trip Purpose							
Social (Friend's Home)	1122	76.9	10.0	7.0	2.2	3.0	1.1
Recreational, Cultural	370	88.8	5.5	2.7	0.9	2.1	0.0
To or From Eating or Drinking Places	874	67.0	14.0	7.3	3.8	5.9	2.0
Between Eating or Drinking Places	105	46.2	19.6	15.6	8.8	7.5	2.3
To or From Work	561	89.2	3.1	4.1	1.6	0.8	1.2
Just Driving Around	68	80.1	3.8	9.0	1.6	5.5	0.0
Other	518	81.2	7.2	3.7	1.9	3.8	2.2
Trip Time							
0-5 minutes	343	76.4	9.0	5.3	2.8	4.7	1.7
6-10 minutes	506	70.9	13.0	8.1	2.6	3.6	1.9
11-20 minutes	1185	76.4	8.4	7.5	2.7	3.8	1.3
21-30 minutes	647	81.6	8.5	5.0	2.1	1.9	0.9
31-50 minutes	426	78.4	9.3	3.7	2.5	4.0	2.2
51-100 minutes	271	82.3	8.3	4.1	1.9	3.0	0.4
101-200 minutes	134	75.7	8.1	6.3	2.0	5.0	3.0
More Than 200 minutes	66	89.5	1.7	7.0	1.8	0.0	0.0

Despite the considerable efforts of many federal, state, and local agencies and citizen groups to try to reduce driving after drinking in the United States, it is apparent that substantial numbers of Americans are still driving while impaired by alcohol. It is hoped that these alcohol countermeasure programs will lead to significant reductions in the percentages of drivers found at impaired BACs in a future national roadside breathtesting survey conducted in the same manner.

Patterns of Blood Alcohol Concentrations Among Drivers

Bernard H. Fox[1,2] and Robert F. Borkenstein

This study represents what was phase one of a research project intended to measure the effects of attempts made to reduce the frequency of driving after drinking in the driving public of a typical county. The plan was to establish a baseline of breath alcohol levels, determine demographic characteristics, describe drinking and driving behaviors, and obtain information on media usage of the drivers. After this a campaign conducted through the various media was to have been carried out focusing on techniques and content that would be most effective for the population of that particular county. Finally, the results of such a campaign were to be measured in a post-treatment survey similar to the baseline survey. For various reasons only the first phase of this three-stage effort was carried out.

The project is useful in its own right in spite of the fact that the last two phases have not been carried out. At the time the study was conducted there existed very few surveys of alcohol levels in a driving population and none of drivers in a rural or semi-rural area. Moreover, in view of the fact that fatal accidents occur with different frequencies on different types of roads, an analysis of alcohol level distribution on the major road types in the chosen county was felt to be of some importance.

Howard County, Indiana, with a population of about 80,000 in 1967, was chosen because of several features. First, it covered a large enough area to include city, small town, and rural drivers. It was isolated enough so that a campaign could be focused rather tightly upon the county and closely surrounding areas from which the driving population derives. Moreover, the bulk of the driving public would be covered in both baseline and after-treatment breath alcohol surveys. Thus overlap and random effects due to drivers intruding from outside areas would be relatively small. It had been determined that police agencies would cooperate fully in this county. It was close enough to the home base (Bloomington) of the project director to allow easy communication among the survey team, the police, and the project supervisors. The county seat, Kokomo, had a population of about 46,000 at that time, and there are several smaller communities in the county as well as a good distribution of state and county highways. Howard County lies in a rich farming belt and has, in addition, light

---

[1] National Cancer Institute, Bethesda, Maryland 20014, U.S.A.

[2] Carried out for the Division of Accident Prevention, USPHS, 1966, under Contract PH 86-67-149. The active phase of the research was conducted under the direction of Professor Borkenstein.

and heavy manufacturing industries in Kokomo. The county is mostly flat, is about 10 miles by 30 miles (293 square miles in area) and lies some 50 miles north of Indianapolis.

SITE SELECTION

Since the traffic density in various parts of the county was unknown, it was not feasible to select sites that were representative of such density in advance of the study. It was therefore decided that a representative area sampling in the county with a guessed weighted frequency of road types would be taken to accommodate the high traffic density of roads such as four-lane highways, as well as the low traffic density of roads such as remote county roads. Since this method of selection is at best an approximation, it was further decided to carry out traffic counts at the interview locations in order to be able, later, to adjust for the ratio of frequency of cars at any site to number of samples. While this ignores further refined adjustment associated with varying ratios according to time of day, and differences in such ratios for different roads of the same type, nevertheless an attempt was made to deal with the differential density problem. In addition to the above reasoning, an important basis for deciding on the method of site selection given below was the need to have some assurance that enough observations on each type of highway would be made to allow stable estimates of breath alcohol distribution.

Four classes of highway were defined: 1) four-lane highways or streets, whether in the city or not; 2) two-lane state and federal highways, whether in the city or not; 3) city streets not otherwise classified as four-lane or two-lane highways; and 4) county roads not otherwise classified. A set of United States Geological Survey maps was available as well as enlarged county and city maps. It was possible to divide the maps, with appropriate overlays, into squares with sides of approximately 1,000 feet. Within cities it was further decided to divide each square into four sub-squares. Each square was serially numbered and an identifying number was associated with each of the streets or highways passing through the given square or sub-square. An accommodation was made to the larger size of the four-lane roads by counting each such road segment within a square twice and within each sub-square once; also, each two-lane state or federal road located in a sub-square was listed only once for passage through the whole square, even though it might have passed through two or more sub-squares. A random sampling procedure was devised which selected an approximately equal number of sites identified with each of the four different types of roads. Samples were taken from 165 four-lane site numbers; 392 two-lane federal or state site numbers; 1,979 city street site numbers and 3,760 county road site numbers. This included the duplicated four-lane site numbers.

The sampling process resulted in a selection of 1,000 road sites from this series. Although we intended to visit almost half of them in order to achieve the projected sample of 3,000 cases, it was only possible to visit 275 sites with a total of 1,919 interviews because of various difficulties and time problems. However, since the sites were visited in sequence from a randomly chosen series which included an approximately equal number of each type of road, no bias was added by the failure to achieve the projected total sample size. The number of sites for each road type was: 4-lane, 73; 2-lane, 73; city streets, 69; county roads, 49. Assuming the total number to be divided equally among the road types, $\chi^2 = 6.00$, $p > .10$, thus supporting the hypothesis of equal expectation. The features of the 11 'unknowns' also support the hypothesis.

THE QUESTIONNAIRE AND PROCEDURE

The questions asked addressed several areas of interest. Among them were demographic data, driving characteristics, drinking behavior, and media usage [3]. Selected data from the total number of items investigated will be presented here. Item form was similar, in general, to that used in Grand Rapids (1), and those found successful there, were used here. However, there were some changes.

Records of responses were set down in shorthand developed for quick coding. The name and occupation of the respondent, and type and make of car were written out in full. A courtesy card was printed that described the project, assured the driver of confidentiality and immunity from arrest, and emphasized the need for the information that was to be asked of him. The card also thanked the driver for his cooperation. Cards were serially numbered. The driver was asked to keep the card for about three months and to present it if stopped again for the same purpose.

The interviewers, two graduate students in the Department of Police Administration, Indiana University, were trained by personnel who had been involved in the Grand Rapids study. The usual instructions were given to them about developing rapport, a positive approach, avoidance of judgment about an interviewee's responses, and need for adaptability. Practice interviews were carried out with a point-by-point discussion after each interview. By arranging their work schedule suitably, it was possible to sample seven days a week.

Interviewers were helped by several Deputy Sheriffs, paid by the hour. These deputies, who always appeared in uniform, stopped the vehicles for the interviewers. They also counted passing vehicles during the interviews, using a hand counter. They were very helpful in locating the best sampling location within the sample road segment. It had been agreed with the sheriff that the deputies would make no arrests while working with the research team. Large trucks and busses were not included in the study. If traffic was very slow, both directions were sampled, but where traffic density was higher only one direction was sampled. The direction was chosen on the basis of the location of the sweep second hand of a watch.

An effort was made to carry out nine interviews at each location. For reasons such as the low density of traffic at many sample sites, fewer than 9 samples were taken on average. A distribution of the number of samples taken at each site for each of the four types of roads is given in Table I.

Alcohol levels were measured by the Borkenstein technique. The 52.5 ml of breath normally used to pass through the oxidizing solution was, instead, passed through tube containing calcium chloride. Any alcohol from this volume of breath was retained in the calcium chloride and was recoverable by a pump that removed any alcohol leaving the calcium chloride when the latter was heated to high temperature. That alcohol was then pumped into a Breathalyzer for analysis. By this means alcohol in a respondent's breath could be retained for as long as three months without loss. None of the samples was allowed to be stored for more than a few days before analysis. Before collecting breath, the sampling device was heated to a temperature high enough to retain any alcohol from the sample in its vaporous phase. This was done by means of a 12-volt heating element connected to the car's cigarette lighter. More than one sampling device could be heated simultaneously by equipping a cable with multiple plugs, thus allowing a heated sample to be available at all times.

---

[3] We wish to acknowledge the contribution of Dr. Jack Haskins, University of Tennessee, in designing the media usage questions.

TABLE I *Amount of Interviews Given at each Site for the Four Types of Roads, Howard County*

Number of Interviews Given at a Site	Number of Sites					
	4-Lane	2-Lane Fed. or State	City Street	County Road	Unknown	Total
1	3	0	6	9	0	18
2	2	2	6	5	0	15
3	1	4	2	5	0	12
4	1	0	2	3	0	6
5	3	0	4	4	0	11
6	6	7	6	5	0	24
7	2	3	0	4	0	9
8	0	1	2	3	0	6
9	50	51	40	11	0	152
10	4	5	1	0	0	10
Unknown	1	0	0	0	11	12
TOTAL	73	73	69	49	11	275

Because of contract constraints and because of the study's focus of interest, it was decided to restrict sampling to the hours of 7 p.m. to 3 a.m. Sampling took place from July 6 through September 16, 1967.

GRAND RAPIDS STUDY COMPARISON

The control sample from the Grand Rapids Study was analyzed for selected comparisons with the Howard County data. Where such comparisons were made, they are indicated on the appropriate Tables. The Grand Rapids data were sorted to produce only cases from 7 p.m. to 3 a.m., and for the months of July, August, and September. Unfortunately, only 457 cases resulted. Nevertheless, this was deemed sufficient for most comparisons, and tests of significance take the smaller samples into account. Thus a direct comparison is possible, although certain other differences may temper the breadth of generalization one might make based on such a comparison, for example, different years, different site locations, and the like.

RESULTS

For this report, we decided to present a limited analysis, based on less than perfect data, and subject to later amendment. The single available tape has not been rerun since its first run when the project was terminated and the first report was submitted (2). It is likely that some fading, alteration, or other results of long storage under non-optimal conditions would have affected the tape data. Other sources of data omission and variation, among them failure of a respondent to answer responsively or consistently, are well known and were known to have been operating here. In any case, we have recorded the unknown data for the reader's inspection. It is evident that little or no change in our conclusions and inferences would be necessary if the 'unknowns' were all filled in. Similar differences in totals for different variables, probably also due to the same variation in availability of good data, can be noted in the Grand Rapids study (1).

Table II shows the number of interviews according to sex and ethnic group in the two studies. A test of significance showed that the proportions did indeed differ, but not in a major way. There was an excess of Blacks in Grand Rapids among males. While definite, this excess was not a powerful influence on the other variables in the picture.

TABLE II *Frequency: Ethnic Group by Sex, Howard County (HC) and Grand Rapids (GR)*

	Sex							
	Male		Female		Unknown		Total	
Ethnic Group	HC	GR	HC	GR	HC	GR	HC	GR
White	1430	329	305	73	18	0	1753	402
Black	74	36	18	5	2	0	94	41
Other	5	3	1	1	0	1	6	6
Unknown	30	1	12	1	24	7	66	66
TOTAL	1539	369	336	80	44	8	1919	457

$\chi^2 = 14.84$, df = 3, $p < .01$
Categories: White, Black + Other; Male, Female; HC, GR

The distribution of alcohol levels for Howard County is given in Table III in unit hundredths of a per cent. Table IV shows the distribution of alcohol levels in the two counties for grouped blood alcohol concentrations (BACs). It is evident that the distributions differed. There was a clear excess at the level .010-.049 g/100 ml (%) in Grand Rapids and a corresponding deficiency in Howard County. A slight excess existed in Grand Rapids at the level .110-.149%.

A comparison of the two study locations in regard to sex and alcohol level (Table V) shows an excess of males in Grand Rapids at the level .010-.049%. A corresponding deficiency among males in that city was found at the lower alcohol level category. A similar excess, although not so prominent, was found among males in Grand Rapids at levels of alcohol above .049%. The relative proportion of females in the various alcohol categories was remarkably similar in the two study locations.

TABLE III *Frequency of Interviewees at Various Alcohol Levels, Howard County*

Alcohol Level g/100 ml	Frequency	Per Cent
.000	1385	72.2
.001-.009	261	13.6
.000-.009	1646	85.8
.010-.019	57	3.0
.020-.029	16	.8
.030-.039	14	.7
.040-.049	17	.9
.050-.059	6	.3
.060-.069	15	.8
.070-.079	5	.3
.080-.089	10	.5
.090-.099	9	.5
.100-.109	3	.2
.110-.119	5	.3
.120-.129	2	.1
.130-.139	3	.2
.140-.149	3	.2
.150-.159	1	.1
.160-.169	2	.1
.170-.179	3	.2
.180-.189	2	.1
.190-.199	0	0
.200-.209	2	.1
Unknown	98	5.1
TOTAL	1919	100.3

TABLE IV *Frequency of Interviewees at Various Alcohol Levels*

	Alcohol Level, g/100 ml							
Place	0-.009	.010-.049	.050-.079	.080-.109	.110-.149	.150+	Unknown	Total
Howard County	1646	104	26	22	13	10	98	1919
Grand Rapids	345	57	8	10	8	5	24	457

$\chi^2 = 40.75$, df = 5, $p < .01$

All categories used in analysis except "unknown".

TABLE V *Frequency: Alcohol Level by Sex, Howard County and Grand Rapids*

	Alcohol Level, g/100 ml															
	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
Sex	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
Male	1321	275	89	52	25	8	21	9	10	8	10	5	63	12	1539	369
Female	310	69	12	5	1	0	1	1	3	0	0	0	9	5	336	80
Unknown	15	1	3	0	0	0	0	0	0	0	0	0	26	7	44	8
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

$\chi^2 = 42.33$, df = 5, $p < .001$

Categories: Male, Female; 0-.009%, .010-.049, .050+ g/100 ml; HC, GR

Representation of different ethnic groups' alcohol levels in the two counties is shown in Table VI. The distributions are definitely different, with the excess showing up in Grand Rapids among Whites at the level .010-.049%. A corresponding deficiency appeared in Howard County. A deficiency for Whites appeared in Grand Rapids at the lowest level of alcohol.

TABLE VI *Frequency: Ethnic Group by Alcohol Level, Howard County and Grand Rapids*

	Alcohol Level, g/100 ml															
Ethnic Group	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
White	1529	316	87	51	21	7	18	6	10	6	8	4	80	12	1753	402
Black	70	26	10	5	4	1	2	4	2	2	2	0	4	3	94	41
Other	4	3	1	1	0	0	1	0	0	0	0	1	0	0	6	5
Unknown	43	0	6	0	1	0	1	0	1	0	0	0	14	9	66	9
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

$\chi^2 = 55.05$, df = 5, $p \leqslant .01$

Categories: White, Other; 0-.009, .010-.049, .150+ g/100 ml; HC, GR

The distribution of Howard County interviewees by age and alcohol level is shown in Table VII. The usual identification of more drinking in the age groups 25-44 was found.

TABLE VII *Frequency: Age by Alcohol Level, Howard County*

	Alcohol Level g/100 ml															
	0-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
Age	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%
15-17	120 7.3	90.0	8 7.7	6.1	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	4 4.1	3.0	132 6.9	100.0
18-19	174 10.6	93.5	6 5.8	3.2	0 .0	.0	1 4.5	.5	0 .0	.0	0 .0	.0	5 5.1	2.7	186 9.7	99.9
20-24	315 19.1	86.5	24 23.1	6.6	4 15.4	1.1	7 31.8	1.9	1 7.7	.3	1 10.0	.3	12 12.2	3.3	364 19.0	100.0
25-34	417 25.3	83.6	27 26.0	5.4	10 38.5	2.0	7 31.8	1.4	4 30.8	.8	4 40.0	.8	30 30.6	6.0	499 26.0	100.0
35-44	259 15.7	79.7	19 18.3	5.8	6 23.1	1.8	4 18.2	1.2	6 46.2	1.8	4 40.0	1.2	28 28.6	8.6	325 16.9	100.1
45-54	207 12.6	87.0	16 15.4	6.7	3 11.5	1.3	3 13.6	1.3	0 .0	.0	0 .0	.0	8 8.2	3.4	238 12.4	99.7
55-64	93 5.7	88.6	4 3.8	3.8	2 7.7	1.9	0 .0	.0	2 15.4	1.9	0 10.0	.0	3 3.1	2.9	105 5.5	100.1
65-74	29 1.8	90.6	0 .0	.0	1 3.8	3.1	0 .0	.0	0 .0	.0	0 .0	.0	2 2.0	6.3	32 1.7	100.0
75+	7 .4	100.0	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	7 .4	100.0
Unknown	25 1.5	80.6	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	6 6.1	19.4	31 1.6	100.0
TOTAL	1646 100.0	85.8	104 100.1	5.4	26 100.0	1.4	22 99.9	1.1	13 100.1	.7	10 100.0	.5	98 100.0	5.1	1919 100.1	100.0

Table VIII compares the alcohol levels for the two counties according to marital status. The distribution for the two counties was clearly different. There was an excess of Grand Rapids interviewees at the .010-.049% level among married and widowed persons as well as among separated and divorced. The usual corresponding lesser deficiency for the same level appeared in Howard County for this group.

TABLE VIII *Frequency: Marital Status by Alcohol Level, Howard County and Grand Rapids*

	Alcohol Level, g/100 ml															
	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
Marital Status	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
Single	480	105	32	13	4	1	8	1	2	1	1	2	32	1	559	124
Married or Widowed	1976	224	66	36	19	6	14	7	9	4	6	3	49	12	1239	292
Separated or Divorced	54	13	5	8	3	1	0	2	0	3	2	0	4	1	68	28
Unknown	36	3	1	0	0	0	0	0	2	0	1	0	13	10	53	13
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

$\chi^2 = 52.8$, df = 8, $p \leqslant .01$

Categories: Single, Married or Widowed, Separated or Divorced; 0-.009, .010-.049, .050+ g/100 ml; HC, GR

A comparison of education level in the two counties again shows a clear difference between the counties (Table IX). At the lowest level of alcohol Grand Rapids shows a major deficiency of those who had finished in 12th grade and a marked excess among those in the same alcohol grouping who had completed eight or fewer years of education. Grand Rapids also showed a clear excess for all educational levels at the BACs .010-.049%.

TABLE IX *Frequency: Education by Alcohol Level, Howard County and Grand Rapids*

Education: Number of years Completed	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
0-7	52	21	2	2	2	0	1	0	2	2	0	0	6	1	65	26
8	97	37	3	6	1	0	2	1	0	1	1	1	3	6	107	52
9-11	367	78	24	15	7	3	4	4	2	2	2	1	15	2	421	105
12	765	111	45	21	8	3	7	2	5	2	3	1	30	6	863	146
13-15	223	60	17	10	4	0	7	2	3	0	3	2	14	0	271	72
16	56	21	2	3	3	2	0	1	0	1	0	0	3	0	64	28
17-21	48	13	5	0	1	0	0	0	1	0	1	0	4	0	60	13
Unknown	38	4	6	0	0	0	1	0	0	0	0	0	23	9	68	15
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

$\chi^2 = 85.32$, df = 11, $p \leqslant .01$

Categories: 0-8, 9-11, 12, 13-21; 0-.009, .010-.049, .150+ g/100 ml; HC, GR

When alcohol levels in the two counties are compared by occupational level, the counties again appear to differ (Tables X and XI). There was an excess of unskilled/semi-skilled as well as skilled persons at the alcohol level .010-.049% in Grand Rapids and a lesser deficiency in Howard County for the first occupational group. Among lower white collar workers, and especially among the unskilled/semi-skilled, Grand Rapids shows an excess at the lowest level of alcohol.

TABLE X *Frequency: Occupational Level by Alcohol Level, Grand Rapids*

	Alcohol Level, g/100 ml															
	0-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
Occupational Level	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%
Unskilled	71 20.6	67.0	17 29.8	16.0	2 25.0	1.9	4 40.0	3.8	4 50.0	3.8	2 40.0	1.9	6 25.0	5.7	106 23.2	100.1
Semi-skilled	40 11.6	78.4	8 14.0	15.7	1 12.5	2.0	1 10.0	2.0	0 0	0	0 0	0	1 4.2	2.0	51 11.2	100.1
Skilled	92 26.7	75.4	16 28.1	13.1	2 25.0	1.6	3 30.0	2.5	3 37.5	2.5	1 20.0	.8	5 20.8	4.1	122 26.7	100.0
Lower White Collar	70 20.3	84.3	7 12.3	8.4	1 12.5	1.2	1 10.0	1.2	0 0	0	1 20.0	1.2	3 12.5	3.6	83 18.2	99.9
Upper White Collar	31 9.0	75.6	7 12.3	17.1	1 12.5	2.4	1 10.0	2.4	0 0	0	1 20.0	2.4	0 0	0	41 9.0	99.9
Professional	28 8.1	93.3	1 1.8	3.3	1 12.5	3.3	0 0	0	0 0	0	0 0	0	0 0	0	30 6.6	99.9
Executive	8 2.3	80.0	1 1.8	10.0	0 0	0	0 0	0	1 12.5	10.0	0 0	0	0 0	0	10 2.2	100.0
Unknown	5 1.4	35.7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	9 37.5	64.3	14 3.1	100.0
TOTAL	345 100.0	75.5	57 100.1	12.5	8 100.0	1.8	10 100.0	2.2	8 100.0	1.8	5 100.0	1.1	24 100.0	5.3	457 100.2	100.2

TABLE XI *Frequency: Occupational Level by Alcohol Level, Howard County*

	Alcohol Level, g/100 ml															
	0-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
Occupational Level	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%
Unskilled/ Semi-skilled	572 34.8	85.6	40 38.5	6.0	11 42.3	1.6	10 45.5	1.5	2 15.4	.3	7 70.0	1.0	26 26.5	3.9	668 34.8	99.9
Skilled	358 21.7	81.4	26 25.0	5.9	6 23.1	1.4	5 22.7	1.1	6 46.2	1.4	2 20.0	.5	37 37.8	8.4	440 22.9	100.1
Lower White Collar	166 10.1	85.1	9 8.7	4.6	3 11.5	1.5	1 4.5	.5	1 7.7	.5	0 .0	.0	15 15.3	7.7	195 10.2	99.9
Upper White Collar	231 14.0	86.8	15 14.4	5.6	4 15.4	1.5	4 18.2	1.5	1 7.7	.4	1 10.0	.4	10 10.2	3.8	266 13.9	100.0
Unclassifiable	311 18.9	91.5	14 13.5	4.1	2 7.7	.6	2 9.1	.6	3 23.1	.9	0 .0	.0	8 8.2	2.4	340 17.7	100.1
Unknown	8 .5	80.0	0 0	.0	0 0	.0	0 0	.0	0 0	.0	0 0	.0	2 2.0	20.0	10 .5	100.0
TOTAL	1646 100.0	85.8	104 100.0	5.4	26 100.0	1.4	22 100.0	1.1	13 100.1	.7	10 100.0	.5	98 100.0	5.1	1919 100.0	100.0

$\chi^2 = 48.01$, df = 8, $p \ll .01$

Categories: Unskilled/semi-skilled, skilled, lower white collar; 0-.009, .010-.049, .150+ g/100 ml; HC, GR (from Table X)

The two counties' distribution of alcohol level according to where the interviewees were coming from is shown in Table XII. However, it was not possible to organize the combination of categories for small frequencies in a meaningful way and therefore no chi-square was calculated for this set of variables. Specifically, however, one might note that at the alcohol level .010-.049% the number of people coming from home was about the same in the two counties, whereas for the lowest level of alcohol there were three times as many coming from home in Howard County as in Grand Rapids. A similar comparison can be made for social visits and work associated travel.

TABLE XII *Frequency: Place of Departure by Alcohol Level, Howard County (HC) and Grand Rapids (GR)*

Place of Departure	Alcohol Level, g/100 ml															
	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
Home	316	101	17	16	3	3	1	1	6	2	2	0	17	7	362	130
Social Visit[a]	391	65	24	14	4	1	4	5	2	3	0	0	11	4	436	92
Work Associated[b]	274	68	12	7	6	0	3	0	3	1	2	1	15	0	315	77
Shopping or Errands[c]	160	52	5	2	1	0	0	0	0	0	0	0	6	2	172	56
Clubs or Meetings	9	2	5	2	5	0	5	0	1	0	4	0	0	0	29	4
Dining	26	9	2	4	0	0	2	0	0	2	0	2	2	0	32	17
Entertainment/ Recreation	274	29	32	10	5	4	6	4	1	0	1	1	11	2	330	50
Other	110	15	2	2	1	0	1	0	0	0	0	0	6	1	120	18
Unknown	86	4	5	0	1	0	0	0	0	0	1	1	30	8	123	13
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

[a] "Friends' or relatives' homes" in Grand Rapids study.

[b] "Occupation-related" combined with "from or to work" in Howard County study.

[c] "Errands" in Grand Rapids study.

Table XIII shows the number of interviewees having different levels of alcohol on different days of the week. In order to do an appropriate test it would have been necessary to combine all levels above .009% for Grand Rapids. This was not felt to be a productive exercise, so no test of significance was done. Within Howard County there appeared to be a remarkable consistency of frequencies within alcohol level groups across the days of the week, whereas this did not appear to be the case for Grand Rapids. However, with such sparse data we could not test such an observation adequately for individual alcohol levels above the lowest.

TABLE XIII *Frequency: Day of Week by Alcohol Level, Howard County and Grand Rapids*

	Alcohol Level, g/100 ml															
	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
Day of Week	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
Sunday	244	54	16	7	3	4	5	3	4	1	2	1	11	1	285	71
Monday	191	49	15	4	3	1	2	0	0	0	0	0	3	4	214	58
Tuesday	227	34	8	7	4	0	4	0	1	0	1	1	7	0	252	42
Wednesday	227	37	12	2	5	1	3	0	2	1	0	0	10	4	259	45
Thursday	259	36	17	6	4	0	3	0	1	2	1	0	12	4	297	48
Friday	262	65	22	9	2	1	4	2	2	1	3	1	16	5	311	84
Saturday	226	70	14	22	5	1	1	5	3	3	3	2	14	6	266	109
Unknown	10	0	0	0	0	0	0	0	0	0	0	0	25	0	35	0
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

The relationship between alcohol level and mileage driven for the two counties is shown in Table XIV. There was a highly significant difference between the study locations. Those with alcohol level of .010-.049% who drove more than 5,000 miles but less than 15,000 per year appeared in excess numbers in Grand Rapids and were deficient in Howard County. Conversely, there was an excess number of drivers with that mileage in Howard County among the lowest alcohol level group and a deficiency among the Grand Rapids group.

The number of people reporting drinking and driving at various frequencies is given by alcohol level for the two counties. No analysis was attempted for these data. Table XV shows the distribution.

TABLE XIV *Frequency: Mileage Driven by Alcohol Level, Howard County and Grand Rapids*

	Alcohol Level, g/100 ml															
Mileage Driven	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
<1000	12	23	0	1	0	0	0	0	0	1	1	0	1	2	14	27
<3000	68	63	5	10	2	2	0	0	0	1	0	0	8	5	83	81
<5000	228		9		1		2		0		1		77		248	
<15,000	850	150	56	32	11	3	10	7	11	4	5	5	30	4	973	205
<30,000	270	58	17	6	7	1	5	3	2	2	1	0	35	1	337	71
>30,000	138	47	11	8	5	2	5	0	0	0	1	0	12	2	172	59
Unknown	80	4	6	0	0	0	0	0	0	0	1	0	5	10	92	14
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

$\chi^2 = 54.12$, df = 8, $p \leqslant .01$

Categories: <1000 - <5000, <15,000, <30,000 - >30,000; 0-.009, .010-.049, .050 + g/100 ml; HC, GR

TABLE XV *Frequency: Reported Drinking and Driving Frequency by Alcohol Level, Howard County and Grand Rapids*

	Alcohol Level, g/100 ml															
Drinking and Driving Frequency	.000-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR	HC	GR
Daily	24	13	6	5	2	0	3	5	1	2	0	4	0	0	36	29
≧3/week	51	24	15	11	3	1	2	1	2	2	1	1	2	0	76	40
≧1/week	151	51	18	23	11	6	12	2	6	2	4	0	14	3	216	87
<1/week ≧1/month	172	59	19	6	3	1	3	2	3	2	1	0	6	2	207	72
<1/month ≧1/year	211	53	8	3	3	0	0	0	1	0	1	0	5	4	229	60
<1/year	16	19	1	2	0	0	0	0	0	0	0	0	0	2	17	23
Never	293	70	14	2	1	0	0	0	0	0	1	0	9	4	318	76
Abstainer	630	56	15	5	0	0	1	0	0	0	1	0	5	9	652	70
Unknown	98		8		3		1		0		1		57		168	
TOTAL	1646	345	104	57	26	8	22	10	13	8	10	5	98	24	1919	457

It was hypothesized that the distribution of cars from different counties of origin would differ according to the streets where they were found. For example, it was felt that in the four-lane and two-lane highways a greater number of out-of-county travellers would be found. A test of the relationship (Table XVI) showed just this kind of discrepancy among roads. There were far more Howard County residents on the city streets and county roads than one might have expected from the proportional totals of county of origin and for different kinds of roads. Similarly, a greater number than expected of other than contiguous-or-Howard counties were found on four-lane highways, and a considerable excess of contiguous residents were found on two-lane highways. Both contiguous and other county residents were markedly deficient on city streets and moderately deficient on county roads.

TABLE XVI *Frequency of Interviews, County of Origin by Road Type, Howard County*

	Road Type 4-Lane		2-Lane (Fed. & State)		City Street		County Road		Unknown		Total	
County of Origin	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%
Howard	322 57.2	25.8	316 53.3	24.6	434 91.2	33.8	200 82.0	15.6	3 11.5	.2	1285 67.0	100.0
Contiguous	114 19.7	32.9	179 30.2	51.6	25 5.3	7.2	28 11.5	8.1	1 3.8	.3	347 18.1	100.0
Other	116 20.0	50.2	87 14.7	37.7	14 2.9	6.1	14 5.7	6.1	0 .0	.0	231 12.0	100.0
Unknown	18 3.1	32.1	11 1.9	19.6	3 .6	5.4	2 .8	3.6	22 84.6	39.3	56 2.9	100.0
TOTAL	580 100.0	30.2	593 100.0	30.9	476 100.0	24.8	244 100.0	12.7	26 100.0	1.4	1919 100.0	100.0

$\chi^2 = 245.67$, df = 6, $p \ll .001$

Categories: Howard, Contiguous, Other; 4-Lane, 2-Lane, City Street, County Road

Because one of the major foci of interest of the study related to habits of media usage in Howard County, frequencies for various usage characteristics were derived. Tables XVII and XVIII show readership and length of readership for morning and evening newspapers. The questions asked of the interviewees had to do with their reading and other media usage behavior on the previous day. It was found that 38% of the sample did not read a newspaper the previous day or their readership was unknown. A similar question about TV watching was asked, and the distributions are shown in Tables XIX and XX. Obviously, data on media usage are available from other sources, but these figures might reflect the usage associated with this particular population, and specifically, this population's drivers. Further analyses might be of great interest to those in the accident prevention area, especially the relation of media usage habits to BACs. We will attempt an analysis of this material later.

TABLE XVII *Number Who Read AM & PM Newspapers, Howard County*

Newspaper Readers	*Frequency*	*Per Cent*
Read both	55	2.9
Read AM only	807	42.1
Read PM only	336	17.5
Did not read or unknown	721	37.6
TOTAL	1919	100.1

TABLE XVIII *Number Devoting Various Times to Reading Newspaper, Howard County*

	AM Paper		PM Paper		Total	
Time devoted to reading newspaper	N V%	H%	N V%	H%	N V%	H%
Less than 1 hour	815 94.5	68.9	368 94.1	31.1	1183 94.4	100.0
Less than 2 hours	19 2.2	59.4	13 3.3	40.6	32 2.6	100.0
Less than 3 hours	3 0.3	42.9	4 1.0	57.1	7 .6	100.0
Unknown	25 2.9	80.6	6 1.5	19.4	31 2.5	100.0
TOTAL	862 99.9	68.8	391 99.9	31.2	1253 100.1	100.0

TABLE XIX *Number Who Watched TV for Various Lengths of Time, Howard County*

Number of Hours Watched	*Number of People*	*Per Cent*
Less than 1	400	20.8
" " 2	277	14.4
" " 3	107	5.6
" " 4	60	3.1
" " 5	36	1.9
" " 6	7	.4
" " 7	6	.3
" " 8	5	.3
" " 9	0	0
" " 10	4	.2
Not watched	788	41.1
Unknown	229	11.9
TOTAL	1919	100.0

Similar considerations apply to radio listening. Data on this behavior are shown in Tables XXI and XXII. The same questions applied to movie watching were also included, and the responses are shown in Tables XXIII and XXIV. This medium seems to have a much smaller potential for messages of value in relation to drinking and driving than the other media. Because the questions asked were not entirely specific, it is possible (although not deemed likely) that there was some confounding among the answers of those who watched movies at a theater and those who saw movies on the TV at home.

TABLE XX *Number Who Watched TV "Yesterday" at Different Times of Day, Howard County*

Time Watched	*Number Watching*[a]	*Per Cent of 1919 Persons Interviewed*
12 pm – 6 am	16	.8
6 am – 9 am	40	2.1
9 am – 12 am	92	5.0
12 am – 3 pm	153	8.0
3 pm – 6 pm	233	12.1
6 pm – 9 pm	453	23.6
9 pm – 12 pm	334	17.4

[a] These numbers include some who watched during more than one time period.

TABLE XXI *Number Who Listened to Radio for Various Lengths of Time, Howard County*

Number of Hours Listened	*Number Listening*	*Per Cent*
1	460	24.0
2	209	10.9
3	106	5.5
4	65	3.4
5	38	2.0
6	40	2.1
7	21	1.1
8	76	4.0
9	9	.5
10	20	1.0
>10	21	1.1
Did not listen	603	31.4
Unknown	251	13.1
TOTAL	1919	100.1

TABLE XXII *Number Who Listened to Radio "Yesterday" at Different Times of Day, Howard County*

Time Listened	*Number Listening*[a]	*Per Cent of 1919 Persons Interviewed*
12 pm – 6 am	255	13.3
6 am – 9 am	419	21.8
9 am – 12 am	373	19.4
12 am – 3 pm	503	26.2
3 pm – 6 pm	482	25.1
6 pm – 9 pm	342	17.8
9 pm – 12 pm	256	13.3

[a] These numbers include those who listened during more than one time period.

TABLE XXIII *Number Who Watched Movie for Various Lengths of Time, Howard County*

Number of Hours Watched	*Number Watching*[a]	*Per Cent*
1	22	1.1
2	9	.5
3	8	.4
4	29	1.5
5	1	.1
Did not watch	1640	85.5
Unknown	210	10.9
TOTAL	1919	100.0

[a] It is possible that some respondents interpreted "watched movie" to include TV movies. Also, these numbers include those who watched during more than one time period.

TABLE XXIV *Number Who Watched Movie "Yesterday" at Different Times of Day, Howard County*

Time Watched	*Number Watching*[a]	*Per Cent of 1919 Persons Interviewed*
12 pm – 6 am	6	.3
6 am – 9 am	4	.2
9 am – 12 am	3	.2
12 am – 3 pm	3	.2
3 pm – 6 pm	7	.4
6 pm – 9 pm	45	2.3
9 pm – 12 pm	43	2.2

[a] It is possible that some respondents interpreted "watched movie" to include TV movies. Also, these numbers include those who watched during more than one time period.

Table XXV shows the distribution of interviews on various types of road according to BAC. A test was carried out to see whether the distribution of alcohol levels differed with type of road. Such a difference did appear statistically, but it does not imply major differences in alcohol distributions among the various types of road. For example, in the horizontal percentage column for the lowest BAC, the variation is relatively small, even though with the large numbers being used, a difference such as that between 82.8% and 90.2% will show significance. Similar observations can be made for the next level of alcohol. All in all, however, there is a fairly stable distribution of proportions throughout this table, and by and large, whatever excess representation of BAC might be found for one or another type of street, it is not very great.

TABLE XXV *Frequency of Interviews, Road Type by Alcohol Level, Howard County*

	Alcohol Level, g/100 ml															
	0-.009		.010-.049		.050-.079		.080-.109		.110-.149		.150+		Unknown		Total	
Road Type	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%	N V%	H%
4-Lane	504 30.6	86.9	27 26.0	4.7	10 38.5	1.7	8 36.4	1.4	4 30.8	.7	4 40.0	.7	23 23.5	4.0	580 30.2	100.1
2-Lane (Fed. & State)	521 31.7	87.9	30 28.8	5.1	7 26.9	1.2	2 9.1	.3	2 15.4	.3	1 10.0	.2	30 30.6	5.1	593 30.9	100.1
City Streets	394 23.9	82.8	38 36.5	8.0	6 23.1	1.3	11 50.0	2.3	5 38.5	1.1	5 50.0	1.1	17 17.3	3.6	476 24.8	100.2
County Roads	220 13.4	90.2	9 8.7	3.7	3 11.5	1.2	1 4.5	.4	2 15.4	.8	0 .0	.0	9 9.2	3.7	244 12.7	100.0
Unknown	7 .4	26.9	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	0 .0	.0	19 19.4	73.1	26 1.4	100.0
TOTAL	1646 100.0	85.8	104 100.0	5.4	26 100.0	1.4	22 100.0	1.1	13 100.1	.7	10 100.0	.5	98 100.0	5.1	1919 100.0	99.9

$\chi^2 = 20.23$, df = 6, $p < .01$

Categories: 4-Lane, 2-Lane, City Streets, County Roads; 0-.009, .010-.049, .050 + g/100 ml

DISCUSSION

It is important to note the method of analysis in most of these Tables. For an m x n x 2 Table in which the two locations were compared, the Table was transformed into an r x 2 Table, where r = m x n. The resulting r x 2 Table then had r–1 degrees of freedom. The expected values were then derived as contingency values from this r x 2 Table. In all χ^2 determinations of this type the "unknown" categories were omitted, both vertically and horizontally. There were two reasons for doing this. First, it could not be assumed that this category was distributed in the same way as the remainder of the list of variables contributing to that marginal total. If there was a bias in the identity of the "unknowns", then this would enter into any χ^2 determination. Second, it was highly probable that Howard County and Grand Rapids differed in the number of "unknown" responses. If this difference turned out to be the main – or even a contributing – source of a significant probability, the contribution of the important variables of interest might be obscured, or even disappear. Such an event would be very distressing, and all the more so if it resulted from circumstantial procedural differences rather than data of interest. Because the "unknowns" were omitted, the number of cases in each determination were smaller than the given marginals by the number of "unknowns" found for each row or column.

A number of difficulties accompany the determination of BACs and the handing out of questionnaires of the kind required in this study. One would be fully justified in being hesitant about making major policy decisions of a precise type based on these data. Nevertheless, it is believed that whatever biases may exist in the results, associated with difficulties already named and many not yet named, it is not likely that a major error would be made by using the figures derived here.

To the extent that the data are no longer current, one might be misled. But similar judgments could be made about any other studies carried out at that time, and policy decisions are still being made on the basis of their results.

A general comparison of the Howard County and Grand Rapids data would be rash. While there is indication that the year-round data were not too different (at least in the distribution of BACs) from the three month data, it has already been shown that there are considerable differences as to time of day, especially when the figures for daylight and darkness are contrasted. In fact, this special selection of time for a sampling frame makes it quite difficult to make an overall comparison between other studies and this one, since their published data are usually 24-hour results. This is a distressing state of affairs.

There is some question as to how representative the data are. For example, during the questioning, or close to its end, it was the deputy's job to stop the next car. If that particular driver, for whatever reason, assumed that the deputy's signal did not mean that he had to stop, then he would go right by the interviewing situation. We do not know how many such passings-by came from a driver's fear of being stopped after drinking. Another aspect of representation was the sampling problem. Since the traffic density was not known at the beginning, the multiplying factor for equating sampling had to be a guess. Except for the county roads, which were somewhat underrepresented, the sampling was, luckily, rather close to the mark. However, because the alcohol level distribution (Table XXIV) did not show marked discrepancies between types of road, the deficiency of sampling for county roads probably had little effect on most variables' association with BACs.

One might have hypothesized that, since a great many rural accidents (as compared with urban ones) are serious and mortal, and, to boot, single car accidents, BACs might be expected to be higher in such rural areas, if alcohol contributed as much to these accidents as to those in the literature. The comparison with Grand Rapids showed that this was not so. There were fewer high level BACs than in Grand Rapids, and more zero or low level BACs.

There is a wealth of data in the product of the original contract, but much work needs to be done to extract from the data inferences of value. Further analyses, however, are beyond the scope of this paper. Also, speculations as to the reasons for differences found are not hard to generate. But these hypotheses were also felt to go beyond our intent in this presentation.

REFERENCES

1. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., and Zylman, R., *The Role of the Drinking Driver in Traffic Accidents.* Department of Police Administration, Indiana University, Bloomington, Indiana, 1963.
2. Borkenstein, R. F., *A Study of the Frequency and Characteristics of Drinking Drivers in a Typical County.* Department of Police Administration, Indiana University, Bloomington, Indiana, 1967.

Patterns of Drug Abuse and Their Relationship to Traffic Accidents

B. M. Kapur[1]

Most drugs seen in cases presented in the emergency rooms of hospitals and those that are involved in traffic accidents are very similar. Apart from alcohol, most of these drugs originate as "over the counter" and prescription drugs. There are very few reports in the literature (1-4) on actual screening of body fluids on non-fatal cases, and a few (5, 7, 9) where a questionnaire type of survey has been done.

Drug screening on a wider scale is now becoming available in most of the hospitals in large metropolitan centres. Some findings concerning cases seen in the emergency rooms of hospitals will be reviewed here and compared with the few published reports in the literature.

In 1962 Wagner (9) questioned 2,060 persons who were under the influence of alcohol and were involved in traffic accidents. He showed that 11% used one or more drugs. A variety of drugs such as gastrointestinal, sedatives, drugs with metabolic effects, spasmolytics, antibiotics, hypnotics, were found. At that time he concluded that a series of investigations should be performed, especially on individuals who were not showing the presence of alcohol.

A number of other such surveys appeared in the German literature (5, 7) in the 1960s. Gupta (4) carried out a ten year survey on barbiturate and other sedative tranquilizers in Ontario, and showed an increase in barbiturates and tranquilizer usage in traffic accidents.

It was in 1968 that Finkle *et al.* (2) did both a questionnaire and a chemical analysis on body fluids of people involved in traffic accidents. They showed that 705 (21%) of the 3,409 drinking drivers had engaged in some concurrent drug usage. The largest categories of drugs were tranquilizers (19.3%), analgesics and antipyretics (15.7%), sedatives and hypnotics (7.5%) and analgesic narcotics (3.8%). Therefore, these categories make up 46.3% of the sample of 705. However, in all, at least 107 different types of drugs were named.

They only performed analyses for drugs other than alcohol on those who showed signs of intoxication but had a blood alcohol concentration of less than 150 mg/100 ml. Out of the 180 cases in this group, 38 (21%) showed the presence of drugs. The categories were: sedative hypnotics 67%, tranquilizers 16%, analgesics 10%. Sedative hypnotics, tranquilizers and analgesics are the recurring names in the different categories reported.

---

[1] Addiction Research Foundation, 33 Russell Street, Toronto, Ontario, Canada M5S 2S1.

The Clinical Laboratory of the Addiction Research Foundation has been analysing body fluids of patients suspected of drug involvement, for the past few years. Samples have been coming to us from the emergency rooms of all the University of Toronto's teaching hospitals and many other hospitals in Ontario. In all cases, unless otherwise specifically requested, a comprehensive drug screening is done. This includes the drugs listed in Table 1, and a screening of any other drug, if requested, is attempted. Techniques used here are Thin Layer Chromatography, Gas Liquid Chromatography and Colourimetric.

TABLE I *Drugs Screened Routinely*

- Amphetamine
- Amitriptyline
- Barbiturates:
  - Amobarb
  - Secobarb
  - Butabarb
  - Pentobarb
  - Phenobarb
  - Barbital
- Bromides
- Codeine
- Chlorpromazine
- Ethyl Alcohol
- Isopropyl Alcohol
- Methyl Alcohol
- Glutethimide
- Methyprylon
- Meprobamate
- Methamphetamine
- Phenothiazine
- Perphenazine
- Phencycledine (PCP)
- Propoxyphene
- Quinine
- Salicylates

TABLE II *Emergency Analyses for Drugs*

	Pattern of Drugs detected (October 1972 - June 1973)	
Barbiturates:		
Single Barbiturate	159	
Barbiturate Combination	132	
Barbiturates + Ethanol	58	
Barbiturates + Other Drugs	22	
Total, alone or in combination	371	371 (39.5%)
Other Sedative-Hypnotics[a]		91 (9.7%)
Ethanol[b]		324 (34.5%)
Salicylates		51 (5.4%)
Salicylates + Ethanol		12 (1.2%)
Opiates or Amphetamine		18 (1.9%)
Phenothiazines		19 (2.0%)
Isopropanol		9 (0.9%)
Other Drug Combinations[c]		43 (4.6%)
TOTAL		938

[a] Sedatives and hypnotics collectively alone or in combination = 487 (51.9%)

[b] Ethanol in combination with other drugs = 419 (44.6%)

[c] Of the 43 "other drug combinations" 25 were sedatives with ethanol

TABLE III *Drugs Suspected and Found in 722 Patient Samples (November 1973 - June 1974)*

Drug	Suspected	Found	Percentage	Number of patients not suspected but positive on screening	% of total number of positives seen in the laboratory
Barbiturate and Non-Barbiturate Sedative Hypnotics					
Barbiturates[a]	215	132	61.3	54	29.0
Methyprylon	34	32	94.1	30	48.3
Methaqualone	30	25	83.3	8	24.2
Meprobamate	5	4	80	4	50
Glutethimide	9	8	89	4	33.3
Ethchlorvynol	8	3	37	2	40
Salicylates and Alcohol					
Salicylates	80	40	50	25	38.4
Alcohol	181	130	71.8	68	34.3
Other Compounds					
Opiates[b]	24	8	33.3	10	55.5
Phenothiazines	35	12	34.2	6	33.3
Amphetamine	12	0	0	4	100
Darvon	4	2	50	1	33
Amitriptyline	19	9	47.3	1	10
P.C.P.	5	2	33	1	33
Demerol	2	2	100	0	0

[a] Amobarbital
Phenobarbital
Secobarbital
Barbital
Butabarbital
Pentobarbital

[b] Morphine
Codeine
Methadone

Over the 9 month period from October 1972 to June 1973, we did a 1,560 case study of which 938 (60.1%) were positive for one or more drugs, including ethanol. Table II shows the patterns of drugs detected in the 938 cases.

A questionnaire type survey (6) has already been shown to be very conservative in that few of the drugs used are reported. Information accompanying the potential overdose case, although helpful, is not sufficient. In trying to find out which drugs must be screened for, and how much one can rely on the information presented to the examining physician, a correlation of drugs suspected to drugs found, was made. This was carried out on patients presented in the emergency room between November 1973 and June 1974. The suspicion of the physician is based on, (a) presenting symptoms, (b) information supplied to the physician, through a friend or the patient himself, and (c) drugs found on the body of the patient. Table III shows these results.

The suspicion proved to be correct for barbiturates 61% of the time. However, 29% of the total positive cases were missed. Methyprylon, a sedative hypnotic, appeared very high on the suspicion list. However, 48% of the total positives were missed. Approximately 37% of the sedative hypnotic compounds were missed. The same holds true for ethanol. Therefore screening for one drug or another on individual patients can easily be ruled out, and a comprehensive drug screening must be performed on every person. The same conclusion applies in the case of traffic accidents.

CONCLUSION

The patterns of drugs seen in the emergency rooms are very similar to those seen in the drinking driver cases. Although not many reports are available, preliminary work (8) has just appeared in the literature. A very large number of cases with drug involvement are seen in hospital emergency rooms. By monitoring the overdose scene in the local hospital, a minimum comprehensive list of drugs could be drawn up. This would not only help towards a more thorough investigation, but would also save time so that the special 'tough cases' can be done by the more sophisticated instrumentation, e.g. Gas Chromatography/Mass Spectrometry/Computer.

REFERENCES

1. Allgen, L-G., Bejerot, N., Bergsman, A., Hellström, L. and Sandberg, A., Alcohol and Drugs in the Blood and Urine of 142 Persons Suspected of Driving while Intoxicated, *Läkartidningen* 70, 1169, (1973).
2. Finkle, B. S., Biasotti, A. A. and Bradford, L. W., The Occurrence of Some Drugs and Toxic Agents Encountered in Drinking Driver Investigations. *Journal of Forensic Sciences* 13, 236 (1968).
3. Finkle, B. S., Drugs in Drinking Drivers: A Study of 2,500 Cases. *Journal of Safety Research* 1, 179 (1969).
4. Gupta, R. C., and Kofoed, J. Toxicological Statistics for Barbiturates, Other Sedatives, and Tranquilizers in Ontario: A 10-Year Survey. *Canadian Medical Association Journal* 94, 863 (1966).
5. Kessler, A. *The Combined Influence of Drugs and Alcohol Threshold Concentrations on Traffic Safety, Based on the Survey of 2,500 Cases.* Dissertation, Medical Faculty of the University of Mainz, West Germany, 1963.
6. Kilbrick, E., and Smart, R. G., Psychotropic Drug Use and Driving Risk: A Review and Analysis. *Journal of Safety Research* 212, 73 (1970).
7. Romeyke, C., *Alcohol and Drugs: Statistical Investigations on Incidence and Effect with Reference to Forensic Medical Blood Alcohol Tests.* Dissertation, Medical Faculty of Christian-Albrechts University, Kiel, West Germany.
8. Turk, R. F., McBay, A. J. and Hudson, P., Drug Involvement in Automobile Driver and Pedestrian Fatalities. *Journal of Forensic Sciences* 19, 90 (1974).
9. Wagner, H-J., Die Bedeutung der Untersuchung von Blut- bzw. Harnproben auf Arzneimittel nach Verkehrsunfällen auf Grund der Überprüfung von 2060 Personen. *Arzneimittelforschong* 11 992 (1962).

Alcohol and Road Accidents in Great Britain

Barbara E. Sabey[1,2] and P. J. Codling

Legislation imposing a legal limit of alcohol in the blood of drivers of motor vehicles was introduced in Great Britain in October 1967 (5). The immediate and substantial reductions in road accidents which followed are well known (1, 6). This paper examines subsequent trends in casualties, looking particularly at the changing patterns over the years for drivers of different ages, for different classes of road user and the importance of hour and day when accidents occur.

In addition to monitoring trends in casualties, based on all reported injury accidents in Great Britain (England, Scotland and Wales), it has been possible to obtain data on blood-alcohol levels amongst a sample of adult fatalities in England and Wales. These major data sources provide indicators to the important features associated with alcohol in road accidents, but in no way attempt to establish causal relationships. Some assessment of the extent to which alcohol impaired drivers are responsible for accidents in which they are involved has more recently been made during the course of extensive local on-the-spot investigations, in which a multi-disciplinary team has attended the scene of accidents, examined vehicles and attendant circumstances in depth, and interviewed drivers.

ROAD CASUALTIES (4)

Method of Assessment of Trends

In the assessing of trends in road casualties, simple comparisons of numbers can only provide useful indications of the effects of the particular legislation concerned if allowance can be made for other interacting factors. Of these, the main ones are traffic growth and composition, changes in weather, and introduction of other road safety

---

[1] Transport and Road Research Laboratory, Department of the Environment, Crowthorne, England.

[2] The work described in this paper forms part of the programme of research of the Transport and Road Research Laboratory, and the paper is contributed by permission of the Director. Thanks are due to the Coroners in England and Wales and The Chief Constables throughout Great Britain for supplying records of accidents and blood alcohol levels.

Crown copyright 1974. Any views expressed in this paper are not necessarily those of the Department of the Environment.

measures. Over the seven year period studied (October 1966 to September 1973) traffic has been growing steadily at a rate of 3 per cent per annum, which indicates that any estimate of benefits from the alcohol legislation in terms of numbers of casualties will be underestimated. Weather in Great Britain has tended to be drier in recent years, and this might account for about 2 per cent reduction in casualties annually. As far as other road safety measures are concerned, there has been no other single measure which might be expected to have as great an impact as the alcohol legislation, but there have been increasing numbers of smaller measures – road improvements, vehicle design changes, legislation, and propaganda – which together could contribute considerable savings in accidents. It is not possible to make an assessment of the overall effect of the smaller measures. Therefore their cumulative effect has been minimised in the assessment of the effects of the alcohol legislation by making comparisons between the numbers of casualties in hours in which "drink and driving" is most prevalent, namely 10 p.m. – 4 a.m., and those occurring during the rest of the day. This is based on the assumption that most road safety measures apply at all times of day, the main exceptions being improvements in street and vehicle lighting.

Overall Trends in Casualties

In the last year before the introduction of legislation (October 1966 – September 1967) there were over 380,000 road casualties reported by the police in the whole of Great Britain, including nearly 8,000 fatalities. The subsequent changes in casualties are indicated in Table 1. Such substantial reductions have been achieved that in the last year recorded there were fewer people killed and injured than six years previously. For the sake of simplicity, only one year before legislation has been used as a basis for comparison in this paper: justification for doing this lies in earlier analyses which indicated that accident rates for 1966/7 were typical of trends up to that time (1, 6).

TABLE I *Trends in Casualties in Great Britain Following the Introduction of Legislation on Drink and Driving*

	Whole day[a]		Main 'drink' hours 10 pm – 4 am		Rest of day	
(Oct-Sept)	Killed	All injured	Killed	All injured	Killed	All injured
No. of casualties 1966-67	7,920	386,690	2,240	82,092	5,677	304,520
			Percentage change relative to above			
1967-68	–15	–11	–36	–34	–7	–4
1968-69	–11	–10	–29	–28	–3	–5
1969-70	– 6	– 7	–20	–21	–1	–4
1970-71	– 2	– 8	–14	–18	+2	–5
1971-72	– 3	– 8	–12	–17	+0.5	–6
1972-73	– 3	– 6	–10	–13	–0.5	–5
No. of casualties 1972-73	7,686	362,509	2,011	71,724	5,655	290,136

[a] Including accidents for which the time of day was not known.

Initially, casualties were reduced by 11 per cent overall, by 34 per cent during the main 'drink' hours and by 4 per cent during the rest of the day; reductions in fatalities were even greater. Subsequently, there have been progressively fewer reductions in casualties relative to 1966/67.

The proportions of casualties in the main drink hours (Table II) which initially were reduced by about one quarter, have been increasing at a rate which, if unchecked, will revert to 1966/67 levels by 1975/76.

TABLE II *Proportions of Casualties in the Main 'Drink' Hours (10 pm – 4 am)*

Percentages in main 'drink' hours	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73
Killed	28.3	21.3	22.5	24.3	25.0	25.7	26.2
Injured	21.2	15.6	17.1	18.1	19.0	19.1	19.8

Types of Road User

The trends in casualties amongst different classes of road users make interesting comparison (Table III). Initially, reductions in motor vehicle driver casualties and passenger casualties were of the same order, as might be expected since passengers are largely the 'victims' of the drivers to whom the legislation applied. The subsequent trends are rather different: reductions in passenger casualties tend to decline less with time than the driver casualties. For pedestrians, the reductions in casualties were fewer initially but there has been much less change over the years and fatalities particularly are still very substantial. The explanation for these different patterns of casualties is complicated by the fact that the data only indicate the types of casualty, regardless of blame. On the one hand, non-drinking road users may be the victims of drinking drivers who are uninjured; on the other, non-drinking drivers may suffer as a consequence of the actions of drinking pedestrians. Further, it is not known how occupancy of vehicles or journeying habits may have changed over the years: whether there are fewer passengers being carried in the 'drink' hours, or whether with the increase in car ownership there are fewer pedestrians at night.

Drivers: Age and Day of Week

Reductions occurred in driver casualties of all ages during the first post-legislation year, the effects generally being more marked for the older drivers. During 'drink' hours the reductions in casualties between 1966/7 and 1967/8 was 24 per cent for the under 20s, increasing to 47 per cent for both the 40-49 and 50-59 age groups.

The percentages of casualties which occurred during the 'drink' hours in each age group are indicated in Figures 1 and 2. While the levels of the various graphs will depend to some extent on exposure (it is known that the elderly drive less at night than during the day and the young more at night), the trends over the years can be assumed to give an assessment of the response of different age groups to the legislation. By 1972/3 the percentages of drivers killed during 'drink' hours were

TABLE III *Trends in Casualties among Different Classes of Road Users*

Casualties (Period Oct-Sept) each year	Main drinking hours 10 pm – 4 am		Rest of day		Percentage in drink hours	
	Killed	All injured	Killed	All injured	Killed	All injured
Motor Vehicle Drivers	*Number*		*Number*			
1966-67	757	34,793	1,788	114,204	29½	23½
	% Change		*% Change*			
1967-68	–39	–35	–10	–6	22½	17½
1968-69	–29	–28	– 2	–6	23½	19
1969-70	–13	–22	+ 4	–3	26	20
1970-71	– 2	–17	+10	–4	27½	21
1971-72	– 1	–15	+ 4	–5	29	21½
1972-73	+ 7	– 8	+ 7	–1	30	22
Passengers	*Number*		*Number*			
1966-67	702	36,544	1,008	86,237	41	30
	% Change		*% Change*			
1967-68	–38	–38	– 3	–5	31	21½
1968-69	–30	–29	+ 7	–5	31	24
1969-70	–21	–21	+ 5	–2	34½	25½
1970-71	–15	–19	+ 7	–5	35½	26½
1971-72	–11	–19	+ 4	–6	37	26½
1972-73	–12	–15	+ 2	–4	37½	27½
Pedestrians	*Number*		*Number*			
1966-67	721	9,465	2,443	76,535	23	11
	% Change		*% Change*			
1967-68	–31	–19	– 5	–1	17½	9
1968-69	–26	–20	– 7	–2	19	9
1969-70	–22	–15	– 4	0	19	9½
1970-71	–22	–14	– 2	–3	19	10
1971-72	–22	–16	0	–1	18½	9½
1972-73	–24	–15	– 3	–3	19	10

higher than in 1966/67 for all age groups under 30, while the corresponding percentages were lower than prelegislation for the older age groups. It may be inferred that the alcohol legislation has had a more lasting impact on the older drivers. It is also perhaps relevant that many of the younger drivers started driving after legislation had come into force, and therefore will not have benefitted from the publicity accompanying the introduction of legislation.

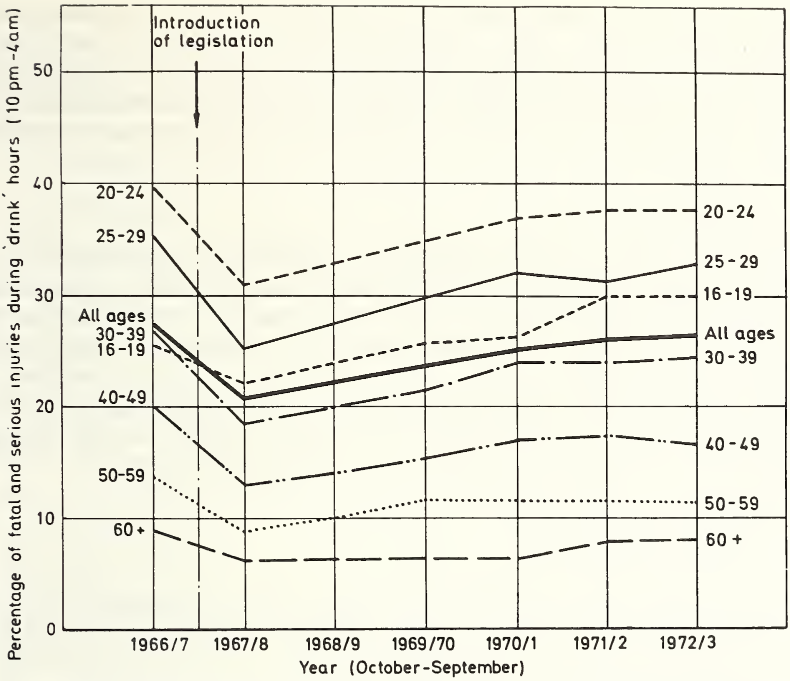


Figure 1 *Motor vehicle drivers killed or seriously injured: percentage during 'drink' hours (10 p.m. – 4 a.m.).*

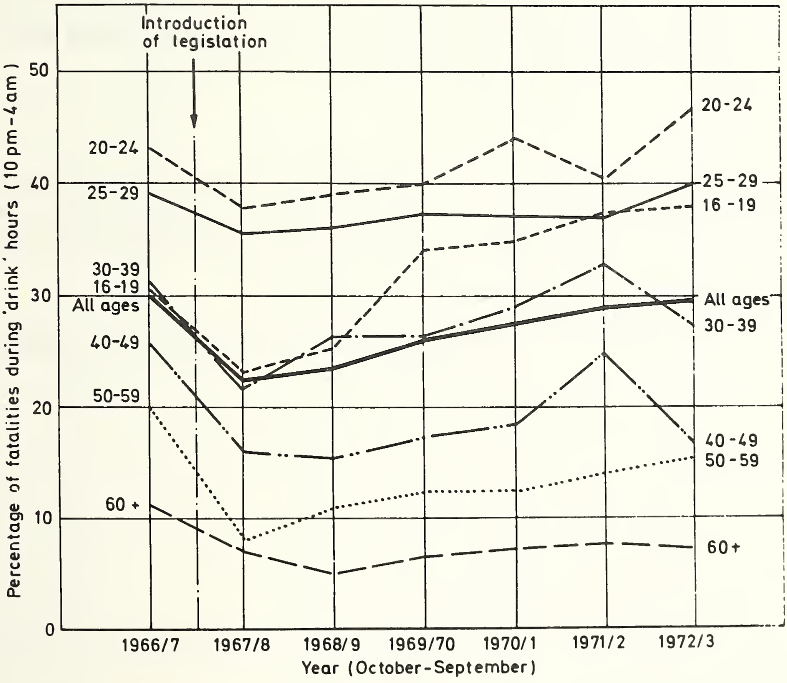


Figure 2 *Motor vehicle drivers killed: percentage during 'drink' hours (10 p.m. – 4 a.m.).*

Reductions in driver casualties occurred on all days of the week being greatest on Saturday nights (initially 44%), next greatest on Friday night (37%), and least on all other nights (of the order of 30% initially). In 1972/3 the numbers of casualties on Friday and Saturday nights were still fewer than in the year preceding legislation, but on other nights the numbers had increased to slightly higher than prelegislation values.

The 1972/73 Situation

The situation regarding the effects of legislation on road casualties for 1972/73 can be summarised by saying that, whilst the initial substantial reduction in casualties have not been maintained, there is still a residual benefit, estimated from Tables I and II to be of the order of 2-3 per cent of road casualties for all severities of injury, and a similar level for fatalities. The situation differs for different types of road users and different ages of drivers. In particular, driver fatalities now seem to have returned to pre-legislation level: for under 30 year old drivers the situation is worse than pre-legislation, whilst for the older drivers there are still substantial benefits.

BLOOD ALCOHOL LEVELS (3)

The legal limit imposed in Great Britain is a blood alcohol concentration (BAC) of 80 mg/100 ml which applies to drivers of all motor vehicles. The only sources of data for BAC levels amongst drivers and other road users are the coroners, who have records of BAC measured for fatalities in road accidents aged 16 years or more and who died within 12 hours of the accidents. There are no data available for less severely injured road casualties, nor for the driving population in general. Nevertheless, the fatality records do provide some useful indicators to the effects of legislation on BAC levels for different ages of drivers and for different types of road users.

Drivers

Distributions of BACs have been obtained for samples of motor vehicle drivers killed since December 1966 (Table IV). Immediately prior to legislation 25 per cent of drivers killed exceeded 80 mg/100 ml, and 37 per cent, within the limit of errors of

TABLE IV *Blood Alcohol Levels for Motor Vehicle Drivers*

Period (Dec-Sept)	Sample size	Percentage with BAC (mg/100 ml) exceeding					
		9	50	80	100	150	200
1966-67	539	37	29	25	22	13	6
1967-68	396	26	17	15	14	9	4
1968-69	460	29	22	19	17	11	5
1969-70	448	30	23	20	17	12	6
1970-71	446	37	31	26	23	15	6
1971-72	310	38	31	27	25	16	8
1972-73	305	44	36	29	26	15	8

measurement, could be said to have been drinking (BAC > 9 mg/100 ml). At the other end of the scale 6 per cent exceeded 200 mg/100 ml. The effects of the introduction of legislation were immediate and substantial. The percentage of drivers killed with BAC in excess of the limit was reduced from 25 per cent to 15 per cent in the first year, but subsequently increased until it equalled the pre-legislation value in 1970/71 and thereafter has exceeded it. A similar pattern of trends holds for all levels of BAC.

Comparison of these data with the accident data in Table III shows that the sample of BACs for fatalities in England and Wales represents about one-fifth of all driver fatalities in Great Britain. Further, the reduction from 25 per cent exceeding the legal limit of 80 mg/100 ml to 15 per cent represents a saving of nearly 500 driver fatalities per year (18 per cent of all driver fatalities) and a total saving of 1,200 fatalities per year for all road users, which is 15 per cent of all fatalities in road accidents.

Examination of BAC levels for different ages of drivers (Figure 3) shows marked age differences. Before legislation the 20-29 age group had the highest proportion of BACs exceeding 80 mg/100 ml. After legislation there were marked reductions in BAC levels, except for the 25-29 age group who were unaffected and retained a high level of drinking throughout. By September 1971 the 20-24 age group had regained the same high level as the 25-29s, namely 40 per cent in excess of 80 mg/100 ml. The youngest and oldest age groups (under 20s and over 50s) were the only ones with percentages below the average prior to legislation, but by 1971 alcohol levels had risen more sharply amongst the under 20s than the over 50s[3].

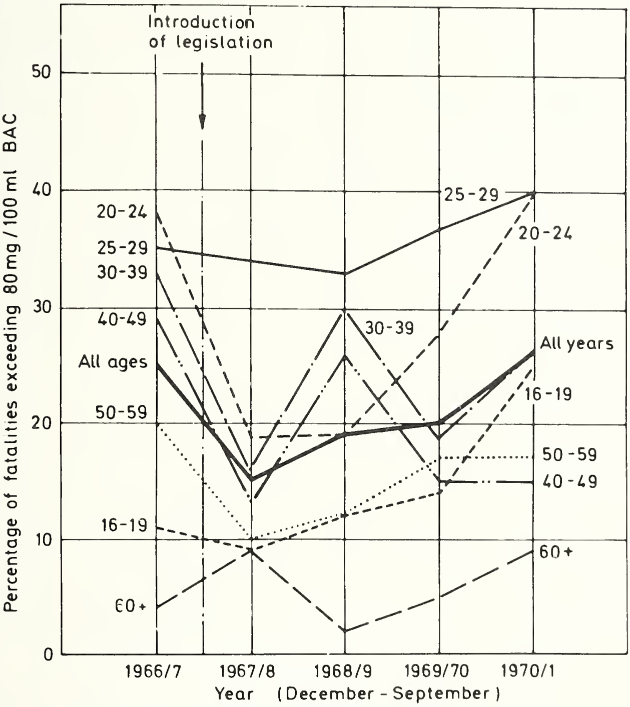


Figure 3 *Motor vehicle drivers killed: percentage exceeding the legal limit of alcohol in the blood (80 mg/100 ml).*

[3] Detailed breakdowns of this kind have not been possible since 1971 because the sample size of data available was greatly reduced.

The results shown in Figures 1, 2 and 3 make interesting comparison. There are some close similarities in the proportions of those exceeding the legal limit of BAC and the proportions of those killed in the 'drink' hours in terms of both trends and levels for different age groups of drivers killed. Some differences exist for which explanations appear possible: for example, the relatively higher levels of percentage of 16-19 year olds killed in the 'drink' hours is likely to reflect only the fact that they drive more at night. On the other hand, there are also some anomalies: in particular, according to BAC records, legislation made little impact on the 25-29 age group, but the percentage of this age group killed in the 'drink' hours was reduced.

Breakdown of the data according to time of day and day of week confirms the high levels of drinking between 10 p.m. and 4 a.m., especially on Saturday nights. By 1970/71 the percentage of drivers killed between 10 p.m. and 4 a.m. who had BACs exceeding 80 mg/100 ml was 60 per cent on average and 70 per cent on Saturday nights. Examination of trends over the years, however, again produces some anomalies when compared with the national accident data. The substantial reductions in drivers killed or seriously injured on Saturday nights immediately following legislation were not apparently matched by reductions in BAC levels amongst fatalities.

Other Road Users

Although legislation did not apply to passengers, pedestrians, and pedal cyclists, it is interesting to look at the changes in BAC levels amongst these road users over the years (Table V). The percentage of passengers killed with BACs exceeding 80 mg/100 ml was reduced significantly from 30 to 17 per cent immediately after the legislation and has not returned to the pre-legislation value. In contrast, the percentage of pedestrians killed with BAC in excess of 80 mg/100 ml was unaffected by the legislation, averaging about 21 per cent. Very few pedal cyclists killed (only about 6 per cent) had BACs greater than 80 mg/100 ml throughout the whole period.

TABLE V *Blood Alcohol Levels for Samples of Passengers and Pedestrians*

Period (Apr-Sept)[a]	Sample size	Percentage with BAC (mg/100 ml) exceeding					
		9	50	80	100	150	200
Passengers							
1967	158	46	34	30	22	12	3
1968	105	39	22	17	16	8	6
1969	133	31	26	17	11	7	4
1970	125	42	33	27	20	14	9
1971	113	40	27	18	15	7	4
Pedestrians							
1967	178	36	27	20	19	11	10
1968	123	33	28	24	23	17	9
1969	170	27	21	19	16	11	9
1970	127	23	18	17	14	10	7
1971	127	33	26	24	21	16	9

[a]Data prior to legislation available only from April 1967

Although legislation did not apply to passengers it is understandable that their BAC levels declined initially if it is assumed that they drink largely as a social activity and that their drinking habits changed in sympathy with those of the drivers whom they accompanied. The subsequent trends in BAC levels and casualties for passengers provide intriguing speculation as to why they, of all road users, seem to have been more greatly influenced by the alcohol legislation over a longer period and, as a class, have a greater residual benefit. Many questions come to mind which can only be resolved by more detailed investigations of habits of drinking and means of travelling on such occasions.

Pedestrians' drinking habits, as indicated by BAC levels amongst fatalities, have hardly changed over the years except for random variations. The levels are in accord with earlier estimates (2) from studies in three local areas in Great Britain (7, 8). Further investigations designed to give a better understanding of the role of alcohol in pedestrian accidents and the interactions between pedestrians and drivers involved are now being undertaken at Birmingham University (2) in conjunction with the Transport and Road Research Laboratory.

ALLOTMENT OF RESPONSIBILITY

Although the statistical studies described indicate broad relationships between alcohol and road accidents, and the importance of alcohol in relation to various characteristics such as age of driver, class of road user and time of day, more detailed investigations are required to establish the extent to which alcohol impairs a driver's performance and contributes to the occurrence of the accident.

In the course of on-the-spot investigations in which factors associated with accidents are examined in detail, the opportunity has been taken to assess drivers' responsibility for the occurrence of accidents and whether their performance is impaired by alcohol. The allotment of blame for the accident is decided after detailed consideration of the circumstances of the accident, the road design and environment, vehicle condition, and many human factors. Responsibility for the accident is attributed to the driver in terms of whether he is primarily or partially at fault, or a victim. Interviews with drivers subsequent to the accident provide information about whether they have been drinking and make it possible to assess whether the effects of alcohol were contributory to the accidents.

Preliminary results of part of the survey (Table VI) provide some very useful indications of the role of alcohol as a causative factor. In a sample of 2,049 drivers involved in 1,164 accidents, the driver was known to have consumed alcohol (alcohol present) in 272 instances, and the amount consumed was considered sufficient to impair driving ability seriously (alcohol contributory) in 118 cases. Comparing these drivers with the whole sample, there were significantly more men 'alcohol-involved' than women; drivers were judged to be primarily at fault much more frequently when they had consumed alcohol (66%) and even more so when their alcohol consumption was judged to have impaired their performance (92%) than in the whole sample (46%). Other features which have emerged are that loss of control and single vehicle accidents are much more associated with alcohol than other types of accident.

This preliminary analysis indicates that at least 13 per cent of drivers involved in accidents had consumed alcohol, and 6 per cent had drunk sufficient to impair their performance seriously. These figures are likely to be underestimates since it was not always possible to interview the drivers. In a subsequent two year survey a much

TABLE VI *Alcohol as a Contributory Factor in Accidents: Results of Depth Investigations*

	Alcohol present		Alcohol contributory		All drivers involved	
	No. of drivers	%	No. of drivers	%	No. of drivers	%
Totals	272	100	118	100	2049	100
Male	254	93	112	95	1766	86
Female	18	7	6	5	282	14
Primarily at fault	180	66	108	92	805	46
Partially at fault	51	19	10	8	432	21
Lost control	128	47	69	58	447	22
Single vehicle accident	96	35	54	46	341	17

higher proportion of drivers was interviewed. Results of this survey for which the analysis is not yet available, will give a much more reliable assessment of blameworthiness.

DISCUSSION

The studies reported here have clearly indicated the magnitude of the problem of alcohol as a factor in road accidents. The immediate response to the introduction of legislation was substantial in terms of reductions in levels of drinking and reductions in casualties in road accidents. Subsequent trends show the fall-off in the effect of legislation on drinking levels, although enforcement has been maintained at a high level and the numbers of convictions per year for exceeding the legal limit of BAC have increased over three fold since the first year of legislation.

How to restore the initial social response of the road user to the legislation can best be resolved when there is a better understanding of drinking habits amongst road users and of the extent to which alcohol-impaired road users are responsible for the occurrence of accidents. This requires more depth investigations of the drinking levels amongst road users, of the nature of their drinking habits, their journeying on the roads and their involvement in accidents.

It is not known whether in Great Britain alcohol-involved casualties are social or 'problem' drinkers, but various evidence suggests it is more the social drinkers involved: for instance, the sympathetic pattern of drinking levels between driver and passenger; the higher incidence of casualties at the times of social gatherings (especially Friday and Saturday nights); the higher levels of drinking among the young than the old; and the low incidence of repeat convictions – only about 4 per cent. However, this is one of the questions which needs to be resolved by further study, along with various anomalies between trends in BAC levels and road casualties which have already been pointed out.

Perhaps one of the most important conclusions of the studies is that, while the overall benefits of legislation have now largely worn off in terms of casualty savings, there is an essential difference between older and younger drivers. The older drivers (30 years and over) still seem to respect the legislation to a considerable extent, while the incidence of high drinking levels amongst younger drivers has increased above pre-legislation level. As pointed out above, it is perhaps relevant that many of the younger drivers (certainly those under 20 years) started driving after legislation had come into force, and therefore will not have benefitted from the publicity accompanying the introduction of legislation.

Another important aspect which requires clarification is the interaction between different road users in terms of both BAC levels and casualty reductions. This is an area which has probably been overlooked because the legislation applies only to motor vehicle drivers. Sufficient evidence is now available to suggest that different types of road user may influence each other's drinking habits. Further, there is clearly a need for much greater understanding of the extent to which drinking and non-drinking road users are responsible for accidents, whether they be drivers, passengers or pedestrians.

Since the introduction of legislation imposing a legal limit of alcohol in the blood of drivers of motor vehicles in 1967, it is estimated that the total savings in casualties over the period of seven years approaches 200,000 injured persons, including over 5,000 fatalities. The initial savings of 42,500 casualties in the first year has now dwindled to an estimated 6,000 casualties in the current year. Past experience has shown that the potential for savings in casualties is at least 10 per cent of the national casualty toll. Further efforts must be directed towards achieving that goal, and one of the first steps already announced (9) is the setting up of a committee of inquiry to study the operation of the law on drinking and driving and to make recommendations.

REFERENCES

1. Beaumont, K. and Newby, R. F., Traffic Law and Road Safety Research in the United Kingdom – British Countermeasures. *National Road Safety Symposium*, Canberra, Australia, March 1972.
2. Clayton, A. B., Alcohol and Adult Pedestrian Fatalities. *17th Conference of the American Association for Automotive Medicine*, Oklahoma, U.S.A., November 1973.
3. Codling, P. J., Blood-Alcohol in Road Fatalities before and after the Road Safety Act 1967. *Department of the Environment, Transport and Road Research Laboratory Supplementary Report 45.* Crowthorne, England, 1974.
4. Codling, P. J., Road Casualties since the 'Drink and Driving' Legislation. *Department of the Environment, Transport and Road Research Laboratory Supplementary Report* (In the press), Crowthorne, England, 1974.
5. Garwood, F. and Johnson, H. D., Statistical Studies leading to the Breath Tests. *Manchester Statistical Society*, England, 1969.
6. Newby, R. F., Casualty reductions in Great Britain following the Road Safety Act 1967. *OECD Symposium on Countermeasures to Driver Behaviour under the Influence of Alcohol and Drugs.* British Medical Association London, September, 1971.
7. Older, S. J. and Sims, M. D., The Incidence of Alcohol in the Blood of some Fatally Injured Road Users. *Ministry of Transport, Road Research Laboratory Report LR 32*, Harmondsworth, England 1966.
8. Rutley, K. S., Alcohol and Road Traffic Accidents. *Ministry of Transport, Road Research Laboratory Report LR 19*, Harmondsworth, England 1966.
9. Saunders, A. B., Seven Years Experience of Blood-Alcohol Limits in Britain. *6th International Conference on Alcohol, Drugs and Traffic Safety*. Toronto, 1974.

Alcohol, Drugs and Carbon Monoxide in Traffic Fatalities in Puerto Rico

Sidney Kaye[1,2]

Traffic fatalities continue to be the largest single cause of death due to accidents in Puerto Rico. Alcohol is the major influencing factor in these fatalities through cases of "driving while intoxicated" (DWI) and "walking while intoxicated" (WWI).

It is generally known (but not willingly accepted) that alcohol is our number one drug problem. In Puerto Rico we have an estimated 100,000 problem drinkers (7) and in the United States, there are an estimated 9 million (21). Alcohol is the highest single cause of death by drug overdose (6, 8, 22); it is exceeded only by heart disease and cancer as a major disease that inflicts man, and as a cause of death by disease (17); it is the highest single common denominator in deaths by violence, *i.e.* suicides, murder, adult accidents (17); and it produces more serious side reactions and organic diseases than any other common drug (such as heroin or the barbiturates). Moreover, it produces serious withdrawal symptoms. (It is estimated that at least 10% of all patients with DTs die abruptly (5).)

In Puerto Rico with a population of about 2.8 million, there are 681,598 registered motor vehicles, 709,996 licensed drivers, and less than 10,000 miles of highway. On these highways there were 85,980 traffic accidents in 1973 that resulted in 30,000 personal injuries and 577 deaths (19, 20). These 577 traffic fatalities represented an increase of 4.5% over the 1972 record of 552.[3] Alcohol continues to play a major role in these traffic deaths.

STATISTICAL DATA

Of the total 577 traffic deaths, we were able to study, in some detail, 508 cases that

---

[1] Professor of Toxicology; Legal Medicine and Pharmacology, Institute of Legal Medicine, School of Medicine, University of Puerto Rico, Puerto Rico.

[2] This investigation was supported by the Puerto Rico Highway Safety Commission, Safety Project AL 52-73-18, and by a Grant from the U.S. Department of Transportation, Federal Highway Safety Administration, Bureau of Highway Safety.

Thanks and acknowledgements due to Drs. Rafael Criado, Marina Sorvill, José M. Vallejo and Néstor A. Loynaz, Forensic Pathologists at the Institute of Legal Medicine; Drs. Bolivar Patiño, José A. Carro, Jesús Vega, René Rigal and Miguel A. Rivera Bonilla, Forensic Pathologists, all of the Island, for their whole-hearted cooperation; and to Statistician Roberto Montañez for the statistical evaluation; to Mrs. Dulce Martínez and Mrs. Carmen Castro; and also to the chemists José Rafael Rodríguez, Carmen I. Navas, Luz Elena Droz, Flor Rosina Mattos and Vanessa Narváez for the alcohol and drug determinations.

[3] In comparison, the first 6 months of 1974 shows a 13% decline over the same period in 1973.

were submitted for measurement of blood alcohol levels and for drug screening following autopsy. Three hundred and eighty autopsies were performed at the Institute of Legal Medicine (School of Medicine) of the University of Puerto Rico. The remaining 128 specimens were sent from other parts of the Island: 64 from the Arecibo District Hospital; 17 from the Fajardo District Hospital; 35 from the Ponce District Hospital; and 12 from Mayaguez-Aguadilla District Hospital.

The 508 traffic fatalities which were studied were separated into the following categories: pedestrians, passengers, drivers, sex, age, occupation, day of the week and hour of the day. Only those persons 15 years old and over, and those who died within 5 hours of the accident were analyzed for presence and amount of alcohol in blood, and screened for common depressant drugs and carbon monoxide.

Regarding the sex ratio for traffic fatalities, these data showed that males outnumbered females four to one. This was the pattern from 1968 through 1971 (9-12). In 1972, the ratio was five to one (7).

Pedestrians

Pedestrians have accounted for the majority of traffic fatalities in Puerto Rico since 1968. They outnumbered both driver and passenger fatalities two to one from 1968 to 1972. In 1973, although they were again in the majority, there were only one and a half pedestrian deaths for each driver and for each passenger death. In 1972, of 404 cases studied, 189 (47%) were pedestrians. Of these, 150 (79%) were male and 39 (21%) female. The following year, 1973, pedestrians accounted for 188 cases (37%) of a total of 508. Again, there were 149 (79%) males and 39 (21%) females. Of these 188 pedestrian fatalities, the age group in which most fatalities occurred was the 61-70 group, with 33 deaths (27 males, 6 females). Regarding occupation, most of the pedestrians studied were labourers; the next largest occupation category was "student", and then "housewife".

Drivers

Drivers accounted for 126 (25%) of the total traffic deaths studied in 1973. Male 'fatal drivers' outnumber female 'fatal drivers' 17 to 1 in that year (119 males, 7 females). In 1972, the proportion was 12 to 1. The age group that contributed the most driver fatalities was 21-30 years, with 41 males and 2 females. As to occupation, most fell into "labourer" category, then "student" and then "chauffeur".

Passengers

Passengers accounted for 120 cases (23.6%). Of these, 77 were male and 43 female.

The remaining 74 cases studied were 9 motorcyclists, 10 bicyclists, and 55 cases where the category was not clearly established.

Hours and Day of Fatal Traffic Accident

Most traffic deaths occurred on Sundays, and the second most on Saturdays, with a total for these two days of 209 (41%). Of these 209 deaths, 181 were males and 28 females. The remaining deaths were distributed over the week in the following manner: Friday, 72 cases; Monday, 51 cases; Tuesday, 47; Thursday 42; and Wednesday, 31. For the remaining 56 cases, the day of the accident was not clearly established. Of the 508 cases studied, 243 took place on the weekend, that is, between 6 p.m. on Friday and 6 a.m. the following Monday.

The distribution by time of day showed that 232 (61%) out of 383 occurred during the night, that is from 6 p.m. to 5.59 a.m. Of these nighttime cases, 164 (71%) occurred between 6 p.m. and midnight. One hundred and fifty-one traffic deaths occurred during the day time. In 125 (25%) of the cases, the hour of the accident was not clearly established. Of the 243 "weekend" deaths, 155 (64%) occurred during the night.

BLOOD ALCOHOL CONCENTRATION

Blood alcohol concentration (BAC) was determined in 386 of the 508 post-mortem examinations. No determinations were made in the remaining 122 cases (a) because an interval of over 5 hours elapsed between accident and death and (b) because no blood alcohol analyses were made on persons under the age of 15 (unless they were drivers).

Positive Alcohol Cases

Only 70 (44%) cases showed positive alcohol content out of the 386 cases analyzed.[4] Of these, 165 (97%) were males and 5 females (ratio, 33:1). (Of the 216 cases that were alcohol negative, 156 were males and 60 females.) In 70 cases (41.2%), the BAC was established at 0.15% or more. Forty-six (27.1%) had 0.10 to 0.14% blood alcohol, and 54 (31.7%) had a BAC of 0.09% or less.

Drivers, pedestrians and passengers. Among the alcohol positive cases, drivers accounted for the majority, numbering 66 or 38.8% (65 males, 1 female). This represents 60% of the 110 drivers analysed for alcohol. Pedestrians numbered 51 or 30% of the 170 alcohol positive cases and 41.8% of the 122 pedestrians tested for alcohol. Twenty-five passengers (23 males and 2 females) were positive alcohol cases. This was

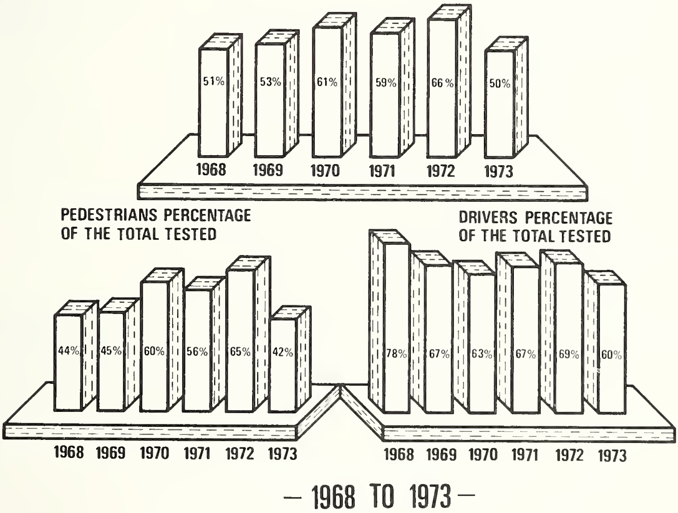


Figure 1 *Percentage of positive alcohol cases of pedestrians and drivers tested.*

---

[4] Blood was used in all cases; urine is unreliable even when using the best of *average* conversion factor (4, 14, 15, 16).

14.7% of the total alcohol cases and 29.1% of the 86 passengers tested. The percentage of positive alcohol cases of pedestrians and drivers for 1973 can be compared to those for the years 1968-1972 in Figure 1.

Day of the week. Sunday accounted for the largest number of positive alcohol cases (47 or 27.6%). Saturday was next with 43 cases (25.3%). Thus, these two days accounted for 52.9% (90 cases) of the 170 cases. The remaining 80 positive alcohol cases were distributed as follows: Friday, 18; Monday and Thursday, 11 each; Tuesday, 9 and Wednesday, 8. In 23 instances, the day of the week was not clearly established.

Hour of occurrence. Out of the 170 positive alcohol fatalities, 102 (60%) occurred during the night. Sixty-three of these happened between 6 p.m. and 12 midnight. Only 23 occurred during the daytime. In 45 cases the hour of the accident was not clearly established.

Day and hour combined. Ninety-nine (57.2%) of these fatalities happened on the weekend, between 6 p.m. on Friday and 6 a.m. on the following Monday. Sixty-three of the night fatalities died between 6 p.m. and midnight.

Age and sex. The largest number of male positive alcohol cases, 46, fell into the 20 to 30 age group, and the largest number of females in the 50 to 60 group (3 cases).

Sex distribution. Amongst drivers, there were 65 males and 1 female; and amongst pedestrians, 50 males and 1 female. The BACs for males and females found in the post mortems in 1973 are compared to those found in the years 1968 to 1972 in Table I.

TABLE I *Number of Post-Mortem Examinations of Traffic Deaths, 1968 to 1973*

Content of Alcohol in Blood	Both Sexes						Males						Females					
	1973	1972	1971	1970	1969	1968	1973	1972	1971	1970	1969	1968	1973	1972	1971	1970	1969	1968
Total	508	404	390	338	262	304	411	334	320	269	213	254	97	70	70	69	49	50
Alcohol Samples	386	242	294	207	179	206	321	207	250	176	149	182	65	35	44	31	30	24
Positive of Alcohol	170	153	163	122	87	96	165	144	156	111	82	92	5	9	7	11	5	4
0.15% or more	70	88	112	76	42	56	68	83	110	68	40	53	2	5	2	8	2	3
0.10% - 0.14%	46	36	29	26	30	25	46	34	26	25	28	24	–	2	3	1	1	1
0.09% or less	54	29	22	20	15	15	51	27	20	18	14	15	3	2	2	2	1	–
Negative of Alcohol	216	89	131	85	92	110	156	63	94	65	67	90	60	26	37	20	35	20
No Alcohol Samples	122	162	96	131	83	98	90	127	70	93	64	72	32	35	26	38	19	26

SCREENING FOR DEPRESSANT DRUGS

In all traffic fatalities, requests were made for blood, urine and bile to allow screening for drugs. Table II shows the number and types of depressant drugs found in traffic fatality cases since 1969. As can be seen, 1973 shows a very great drop in number of such cases. This coincided with a general decrease in total drug overdose fatalities for that year (Table III).

A point of interest is the absence of morphine in 1973, compared to previous years. This too paralleled a decline in deaths due to morphine overdose from 33 in 1970 to 2 in 1973 (Table III).

The three positive cases in 1973 were all due to phenobarbital (less than 2 mg/100 ml) and all proved negative for alcohol. Of these three, one was a female driver, one a male passenger, and the third a male pedestrian.

TABLE II *Depressant Drugs Found in Traffic Fatalities, 1969 to 1973*

Type of Drug	Frequency 1969	1970	1971	1972	1973	Total
Meprobamate	–	1	–	–	–	1
Butobarbital sodium (Butisol)	–	–	1	–	–	1
Fiorinal (Sandoptal)	1	–	1	3	–	5
Diphenhydramine hydrochloride (Benadryl)	–	1	–	–	–	1
Glutathimide (Doriden)	1	–	–	–	–	1
Morphine	6	2	4	1	–	13
Phenobarbital	2	–	1	2	3	8
Phenothiazine	–	4	6	3	–	13
Chlorpromazine (Thorazine)	1	–	–	–	–	1
Methanol	–	2	–	–	–	2
TOTAL	11	10	13	9	3	46

TABLE III *Number of Fatal Poisonings Determined at the Institute of Legal Medicine*

Poison	1966	1967	1968	1969	1970	1971	1972	1973
Parathion (deriv.)	30	19	28	43	37	33	20	17
Morphine (deriv.)	7	15	18	29	33	33	8	2
Ethanol (alcohol)	8	7	7	11	23	11	30	9
Barbiturates (deriv.)	3	3	12	12	9	15	10	5
Phenothiazines	0	1	6	3	7	3	6	5
Tofranil	0	1	0	0	0	2	0	2
Carbon monoxide	3	1	2	5	3	1	10	2
Strychnine	4	3	2	5	2	0	1	1
Phosphorus (Y)	5	2	1	1	2	0	2	1
Librium	1	1	1	1	0	7	2	2
Doriden	0	3	1	4	4	1	1	0
Arsenic	1	1	0	0	1	1	2	0
Methanol	1	1	0	10	1	0	0	0
Salicylates	0	0	0	1	0	0	0	0
Serax	0	0	0	0	0	0	2	0
Various	6	2	5	5	5	2	10	21
TOTAL POISONS	69	60	83	130	127	109	104	67
TOTAL DEATHS (Puerto Rico)	17,509	16,585	15,721	16,850	18,080	18,050	18,200	19,257
POPULATION (In millions)	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8
AUTOPSIES (Institute of Legal Medicine	2,106	1,847	1.932	1,991	2,020	2,759	2,916	3,213

CARBON MONOXIDE AND TRAFFIC FATALITIES

Since carbon monoxide is so directly related to the automobile, we initiated a screening of blood for carboxyhemoglobin in driver and passenger fatalities to see how many would be positive for 5% carboxyhemoglobin (COHb) or more. This was done in spite of the fact that there is no evidence that carbon monoxide has any adverse effect on driving ability.

We found 22 cases with COHb levels of 5 or more mg/100 ml. Of these, 13 had a BAC .05% or over (Table IV). The presence of carbon monoxide in the blood can be explained by car exhaust deficiencies and even, in part, to smoking.

A recent report by Anderson *et al.* (1) indicated a possible influence of low levels of COHb. In an experiment, they exposed 10 patients with diagnosed angina pectoris to very small amounts of carbon monoxide, producing 2 to 4% carboxyhemoglobin. These low levels caused a decrease in exercise tolerance and worsening of myocardial ischemia in all 10 patients.

Another series of experiments was reported by Aronow and Isbell (2) who also exposed 10 patients with angina pectoris to 50 ppm of carbon monoxide for 2 hours. This produced a COHb concentration of 2.6%. These patients were shown to induce angina sooner, and with less cardiac work.

TABLE IV *Carbon Monoxide in Traffic Fatalities (1973)*

Carbon Monoxide Only		Carbon Monoxide plus Alcohol	
No. of Cases[a]	COHb	No. of Cases	BAC
10	5%	6	0.05%-0.10%
10	10%	4	0.11%-0.15%
1	15%	1	0.16%-0.20%
1	20%	2	0.21% and over
22 (21 males, 1 female)		13	

[a] Eighteen died instantly and 4 died within 1 to 5 hours.

Since carbon monoxide, even in small amounts (2-4% COHb) is suspected of producing hypoxia with acute residual heart damage, we can ask what effect a higher exposure to carbon monoxide can have on driving. Also, since the brain cells are extremely sensitive to oxygen deprivation, what does this mean in terms of subtle influence on the central nervous system and driving? Also, alcohol is thought to produce heart hypoxia and even a single cocktail is now denied to many heart patients. Further study of the effect of alcohol in combination with small amounts of COHb in relation to the safe operation of a motor vehicle would seem to be called for.

TEENAGERS AND ALCOHOL-RELATED TRAFFIC FATALITIES

A recent statement made by Morris Chafetz, Director of the National Institute of Alcohol Abuse, that drinking among the 16 to 20 year olds has risen sharply (21) is a matter of great concern. This increase in drinking among adolescents may be partly attributed to the permissiveness of their parents who see alcohol as an acceptable substitute for the hard drugs.

Chafetz' statement, together with a report in the 1974 liquor handbook (the industry's most authorative publication in Puerto Rico) that white rum is extremely popular with young people (20) made us interested to gauge the incidence of alcohol related traffic fatalities in the 16 to 20 age group in Puerto Rico, an island with abundant and excellent rum. The incidence of 15-20 year olds in general traffic accidents is given in Table V and cases related to alcohol are shown in Table VI.

TABLE V *Number of Fatalities for 15-20 Year Olds, 1970 to 1973*

	1970		1971		1972		1973	
Categories	Male	Female	Male	Female	Male	Female	Male	Female
Driver	6	0	9	0	8	0	17	1
Pedestrian	8	1	9	2	8	0	11	4
Passenger	9	3	9	4	13	7	13	9
Motorcycle	4	0	1	0	4	1	3	0
Bicycle	1	0	1	0	2	0	2	0
TOTAL	28	4	29	6	35	8	46	14
Positive for alcohol	6	0	5	0	9	0	9	0

TABLE VI *Cases of Traffic Fatalities with "Positive Alcohol" among 15-20 Year Old Males, 1970-1973*[a]

Year	BAC	N	Categories	Ages
1970	0.15% or more	2	Passenger	16, 18
	0.10%-0.14%	2	Driver	17, 18
		2	Passenger	18, 20
1971	0.15% or more	1	Pedestrian	17
	0.10%-0.14%	3	Driver	16, 18, 19
	0.09% or less	1	Passenger	20
1972	0.15% or more	2	Driver	19, 20
		1	Motorcycle	20
		1	Passenger	19
		1	Pedestrian	15
	0.10%-0.14%	1	Passenger	15
	0.09% or less	2	Passenger	17, 20
		1	Pedestrian	18
1973	0.15% or more	2	Driver	17, 18
	0.10%-0.14%	1	Driver	18
		1	Passenger	16
		1	Pedestrian	18
	0.09% or less	3	Driver	17, 20, 20
		1	Passenger	19

[a] There were no females in the group with "positive alcohol".

The small number of teenagers in our series hardly justifies any serious conclusions so far, but it is sad that youths (all male) are starting so early on a drinking pattern which can only lead to tragedy. It is the heavy drinking, adult male in Puerto Rico who continues to contribute to most of our traffic fatalities. He must be identified and helped.

REFERENCES

1. Anderson, E. W., Andelman, R. J., Strauch, J. M., Fortuin, N. J. and Knelson, J. H., Effects of Low Level Carbon Monoxide Exposure on Onset and Duration of Angina Pectoris. *Annals of Internal Medicine* 79, 46 (1973).
2. Aronow, W. S. and Isbell, M. W., Carbon Monoxide Effect on Exercise Induced Angina Pectoris. *Annals Internal Medicine* 79, 392 (1973).
3. Chavetz, M., Teenage Drinking Rising Sharply. *American Medical Association News,* July, 1974
4. Ellerbrook, L. S. and Van Gaasbeck, C. B., The Reliability of Chemical Tests for Alcohol Intoxication, *Journal of the American Medical Association* 122, 996 (1943).
5. Harris, L., Professor and Director, Department of Pharmacology and Toxicology, Medical College of Virginia Medical Center – Personal communication.
6. Hennegar, G., Professor and Head, Department of Pathology, University of South Carolina; and Mann, G. T., Chief Medical Examiner, Miami, Florida – Personal communications.
7. Kaye, S., Influence of Alcohol on Traffic Deaths in Puerto Rico 1972, *Boletin Asociacion Medico Puerto Rico* 65, 135 (1973).
8. Kaye, S., Changing Patterns of Poisoning in Puerto Rico – Alcohol the Number One Drug Problem in 1972. *Boletin Asociacion Medico Puerto Rico* 66, 64 (1974).
9. Kaye, S., Correlation of BAC and Fatal Traffic Accidents in Puerto Rico (1968). *3rd Triennial Congress: International Association for Accident and Traffic Medicine*, May 1969, N.Y.C.
10. Kaye, S., Alcohol and Drugs Influence on Traffic Deaths in Puerto Rico (1969). *7th International American Conference on Toxicology (Symposium on Alcohol)*, University of Miami, August, 1970.
11. Kaye, S., The Drunk Pedestrian and Driver on Our Highways in Puerto Rico (1970). *Boletin Asociacion Medico Puerto Rico* 63, 170 (1971).
12. Kaye, S. Influence of Alcohol and Drugs on Traffic Fatalities in Puerto Rico (1971). *Fourth Congress International American de Prevención de Riesgos Professionales,* San Juan, Puerto Rico, May 1972.
13. Kaye, S., Alcohol and its Effects on Man. *Boletin Asociacion Medico Puerto Rico* 63, 302 (1971).
14. Kaye, S., *Observations on the Determination of Ethyl Alcohol.* Thesis: Medical College of Virginia, 1955.
15. Kaye, S. and Cardona, E., Errors of Converting a Urine-alcohol Determination to a Blood-alcohol Level. *American Journal Clinical Pathology* 52, 577 (1969).
16. Larson, C., Alcohol, Fact and Fallacy, Chapter in the *Legal Medicine Annuals*, Cyril H. Wecht, (Ed.), Appleton-Century-Crofts, New York, pp. 241-268.
17. Lundberg, G., Pathologist, University of South California, Los Angeles Medical Center; and Dr. Michael Baden, Deputy Chief Medical Examiner, New York City – Personal communications.
18. Moscoso, T., Administrator of Puerto Rico Economic Developement Administration, The Editorial Forum of the San Juan Star, August 6, 1974.
19. Police Department, Commonwealth of Puerto Rico, files.
20. Public Works and Transportation Department, Commonwealth of Puerto Rico, files.
21. Reports from the U.S. Public Health Service; and U.S. Department of Transportation; and Medical News reports.
22. Wiecking, D., *CME; Annual report of the Office of the Chief Medical Examiner,* Commonwealth of Virginia, 1973.

Alcohol, Marijuana and Other Drug Patterns Among Operators Involved in Fatal Motor Vehicle Accidents

Robert S. Sterling-Smith[1]

For the past 30 months the National Highway Traffic Safety Administration has contracted the Boston University Traffic Accident Research Team to conduct an extended psycho-social investigation into the historical and focal variables associated with the operators of motor vehicles judged to have been "most responsible" for a vehicular accident resulting in a personal fatality in the greater Boston area. The initial purpose of the research was to evaluate the extent and degree of alcohol involvement, as well as the relationship between alcohol and other drugs, as they correlated with highway fatalities. The course of investigation was to conduct a multidisciplinary dimension of research into the backgrounds and focal human factors for the "most responsible" operators of each fatal vehicular accident that took place within the geographic limits of the study. The scope of case collection was to include deceased and surviving operators irrespective of alcohol and/or other drug involvement in the focal accident. In every case the primary focus of research was on the single operator judged to have been "most responsible" for the focal accident.

Early in the research three major types of accident-involved operators were identified and classified as follows: A TYPE I operator was one who was himself killed in the focal collision. A TYPE II operator was one who survived the crash himself but was "most responsible" for the death of another vehicular occupant and a TYPE III operator was one who struck and killed a pedestrian. Other types of accidents investigated during the field investigations were accidents precipitated by a "most responsible" operator's heart attack and hit-and-run pedestrian accidents where the operator of the striking vehicle was never apprehended.

METHOD

The research design for the collection of the data called for initial notification of a fatal vehicular accident through the Massachusetts Registry of Motor Vehicles. Following the alert, the Boston team began collecting data from a variety of sources including: police records, medical, social, and legal records as well as reports from the Chief Toxicologist of the Commonwealth, and Probation and Arrest Histories from the Registry. Personal interviews were arranged with survivors, peers and professional counterparts and with surviving operators in an attempt to score the nearly 300 variables collected on each "most responsible" operator. The assembled data were scored in a *Human Factors Index* devised by the Boston team and subsequently transferred to computer cards for analysis and evaluation.

---

[1] Traffic Accident Research, Boston University Law School, Boston, Massachusetts, U.S.A.

The Boston research team was composed of a number of trained specialists from various disciplines. The most sensitive area of investigation came in the dimension of the personal interviews. Each prospective informant was carefully matched with a psychosocial professional in an attempt to secure the reliability and validity of the data. Complete confidentiality was assured for the protection of the informants, particularly in the light of pending civil and criminal litigations. Each personal interview was preceded by a letter to the prospective informant, stating the purpose of the research with an appeal to the altruistic nature of the study. Special cultivation of key lawyers and consultant groups helped in securing the often necessary legal clearance prior to judicial action. Telephone interviews were especially helpful in collecting and validating the data and, most particularly, when followed with a personal interview in a location selected by the informant. This methodology proved to be extremely successful. Only 6 cases collected over the 30 month period were found to have insufficient data and therefore could not be included in the total case load. The correlated data from all sources, often including many personal interviews, was transferred to the *Human Factor Index* for computerization.

Other professionals contributing to the Boston research included: the Chief Medical Examiner from Suffolk County, the Commonwealth toxicologist inspectors from the Registry of Motor Vehicles, local and state police officials, cooperating hospitals and local physicians, medical records supervisors, a wide variety of social workers affiliated with welfare and treatment facilities, consulting statisticians, computer programmers, local clergymen and funeral directors.

ACCIDENT OPERATOR TYPES

The following findings come from an analysis of selected, relevant variables chosen for the present discussion. The 267 cases under consideration represent: 103 (38%) TYPE I "most responsible" operators who were killed in the focal collision, 63 (24%) TYPE II operators who survived the collision for which they were judged to have been "most responsible" but where another vehicular occupant was killed in the crash, and 101 (38%) TYPE III operators who struck and killed a pedestrian. As mentioned above, the 20 operators whose accidents were precipitated by heart attacks and the 13 hit-and -run pedestrian fatal collisions have not been included in the current analysis to assure the clarity of the data and presentation.

The sexual distribution for the entire sample showed 236 (88%) were males and 31 (12%) were females. The sex distribution did not differ at all significantly between the 3 separate operator groups. The mean age for all operators was 32 years of age, with the TYPE I operator group having a mean age of 34 years, the TYPE II operator group 25 years and the TYPE III operators 33 years. The clear modal decade for the total sample and for each accident operator type was in the 20-29 year old category. There was, as might be anticipated, a significant difference in mean ages among the groups with the TYPES I and II operators falling into the same basic age categories and the TYPE II operator group being significantly younger than the other two groups (F 8.450, df 2, $p < .01$).

All three operator type groupings were largely composed of unmarrieds (62%) with the principle concentration of unmarried operators falling into the TYPE II operator group (F 5.322, df 2, $p < .01$). Operators with a high school education or less dominated the sample (72% or 192) with a significantly higher level of education attained by the TYPE I operators (F 3.407, df 2, $p < .05$). As might be anticipated with the significantly younger TYPE II operator group, the level of professional attainment was lower than that achieved by the TYPE I and III operator groups. The mean occupational level of the TYPE II operators was in the direction of being skilled manual employees, whereas, the TYPE I and III operators were significantly higher with their professional status concentrating in the category of clerical workers, technicians, sales persons, and owners of very small businesses (F 4.159, df 2, $p < .05$).

The three operator type groups did not differ significantly in their historical patterns of alcohol use when classified on a 6 point scale ranging from abstainers to alcohol abusers. There were differences between groups when the total scope of variables collected by the Boston team dealing with domestic, social and professional problems arising from alcohol use were compared item by item. They did not differ significantly when the 3 groups were evaluated for normal patterns of pharmaceutical and street drug use, but did differ in patterns of marijuana use with the TYPE II operator showing considerably more frequent smoking patterns (F 4.032, df 2, $p < .05$).

The remainder of this paper discusses the findings of the Boston team particularly as they relate to the analyses of the use of these 4 drug categories, alcohol, marijuana, pharmaceuticals and street drugs, as well as their respective environmental interactions as their use relates to the "most responsible" motor vehicle operator involved in a fatal vehicular collision. Rather than elaborate on the accident operator type groupings mentioned above, the team has chosen to categorize the 267 "most responsible" operators irrespective of who was killed in the crash, from the perspective of their evaluated alcohol and other drug influence at the time of their focal vehicular accident.

The total sample included 122 (46%) of the "most responsible" operators judged to have been influenced by alcohol at the time of their fatal accident with 145 (54%) of the "most responsible" operators evaluated as not having been influenced by a commercial alcoholic beverage at the time of the focal crash. Included in these 2 alcohol groups were 59 (22%) operators evaluated as having been influenced by another drug (marijuana, a street drug or a pharmaceutical), with and without the appending influence of ethol alcohol.

Alcohol Related Accident Operators

Let us first examine the alcohol related accident operators. As mentioned above, 46% of the sample had been drinking before the fatal accident and 54% of the operators were not known to have been influenced by alcohol to any degree. The range of alcohol influence was spread from very mild influence to very severe influence. In the Commonwealth of Massachusetts legal restrictions make it impossible to draw blood for forensic purposes from a surviving operator without the donor's written consent. Such consent is rarely given. That being the case, legal blood alcohol concentrations (BAC) were received from the chemistry laboratory for 98 (37%) of the operators, with only 67 (25%) of the total sample receiving a positive reading ranging from .02% through .49% with a mean reading of .11%. For the remaining 169 (63%) of the "most responsible" operators a wide variety of focal alcohol related variables allowed the team to make a clinical evaluation of the presence and the level of influence of alcoholic beverages.

A wide variety of the data selected for discussion here did show very significant differences between the alcohol influenced operators (Group A) and the operators without known alcohol influence (Group B). The two groups did not differ in the areas of basic demographics, such as sex, age, race, marital status, education, or level of professional attainment. Nor did they differ in such areas as family backgrounds, psychological or physical health histories.

Although the two groups did not differ in their professional psychiatric care histories, they were significantly different when many of the variables associated with societal attitudes, personal relationships and anger/hostility behaviors were correlated. Group A (focal alcohol influence) preferred to spend their leisure time with friends rather than with families ($p < .01$) but, even so, they were not considered by their friends and peers to have been any more popular than the operators in Group B (no alcohol influence) (p = ns). The operators in Group A were decidedly more anti-religious ($p < .01$); anti-establishment ($p < .05$); if married, they were more likely to have had a larger number of domestic problems ($t=3.148$, df 265, $p < .01$) and have recently considered the possibility of marital separation ($p < .01$); if unmarried, they were more likely to have been divorced or separated as opposed to single or widowed ($p < .01$). Group A included in its number more individuals who had a history of chronic unemployment ($p < .05$) with a mean average of 2 job changes during the past 5 years as opposed to less-than-one occupational change for the operators in Group B. The alcohol involved "most responsible" operators, Group A, were also judged by informants to have been more high strung and sensitive ($p < .01$) and had a significantly greater likelihood of having made at least one suicide attempt in their personal history ($t=2.736$, df 263, $p < .01$).

For some time the Boston team has investigated the relative degrees of risk-taking behaviors, the hypothesis being that there might be some risky behaviors typical of certain groups of motor vehicle operators which could assist in the early identification of the high risk driver. The original risk hypothesis was precluded by the observation that all people participate in some variety of risk taking behaviors. In essence such behaviors are an important element in an individual's ability to cope with his environment, consciously and unconsciously. Therefore, the term risk does not necessarily connote anti-social personalities or 'badness'. Instead risky behaviors may indicate coping strategies, acting out mechanisms and other environmental adaptions completely acceptable in a social setting. The number of risky behaviors present in any community could well make the preparation of a risk scale prohibitive by volume. Therefore, from among the many alternatives the Boston team selected 12 groups of risk taking behaviors for inclusion in the Risk Taking Behavior Scale (RTBS). Projected surveys using a 'normative' population may soon allow this scale predictive value in identifying the high risk motor vehicle operator. The experimental RTBS was distributed to 100 highway safety officials, mental health professionals and selected individuals in the greater Boston area representing the general population of the subjects in the fatal accident study. Each participant was asked to rate the 12 group items according to the relative degree of riskiness. The results of this exposure study have produced 3 items of high risk (given a weighting of 3 points), 6 items of moderate risk (given a weighting of 2 points) and 3 items of low risk (given a weighting of 1 point). The high risk items included: 2 or more citations for driving a motor vehicle to endanger or for speeding; the personal use of alcohol to a degree where it becomes a 'problem' socially, professionally or domestically; and having received 1 or more citations for participation in a violent crime. The moderate risk items included: automobile or motorcycle racing; a history of one or more known suicide attempts; ignoring the advice of a physician or medical facility; the abusive use of pharmaceutical drugs; any use of street drugs; and employment in a profession that constitutes relative occupational hazard. The low risk items included: the normal operation of a motor vehicle without the use of restraints; smoking more than 2 packages of cigarettes daily; and smoking marijuana (Table I).

TABLE I *Risk Taking Behavior Scale (RTBS)*

Type of Risk	Group A[a] N	Group A[a] %	Group B[b] N	Group B[b] %
HIGH RISK (weighted 3)				
1. 2 or more citations for driving to endanger or speeding	30	25*	19	13
2. problem drinking	73	60**	33	23
3. 1 or more citations for a violent crime	16	13	11	8
MODERATE RISK (weighted 2)				
4. automobile or motorcycle racing	27	22	26	18
5. 1 or more suicide attempt	23	19**	11	8
6. ignoring medical advice	24	20	18	12
7. abusing pharmaceutical drugs	13	11*	5	3
8. using street drugs	55	45**	40	28
9. hazardous employment	4	3	6	4
LOW RISK (weighted 1)				
10. driving without restraints	110	90**	113	78
11. smoking more than 2 packages of cigarettes daily	33	27	25	17
12. smoking marijuana	62	51**	49	34
WEIGHTED RISK MEAN[c]	6.998		5.401	

[a] Group A = focal alcohol involved operators
[b] Group B = no focal alcohol involvement
[c] $t = 6.007$, df 265, $p < .01$
* $p < .05$
** $p < .01$

The application of the RTBS to the 2 groups of motor vehicle operators under consideration here showed that the operators in Group A (focal alcohol involvement) presented a total mean weighted risk score of 7.0 as opposed to a similar score of 5.4 for Group B (no focal alcohol involvement) for a significant difference between groups ($t=6.007$, df 265, $p < .01$). This finding would then indicate that when considering the 12 group items included in the RTBS the group of motor vehicle operators with focal alcohol involvement had a greater number of risky behaviors included in their pre-accident histories.

Seven of the 12 items showed Group A as having received a larger number of positive responses when each of the items was evaluated individually. Group A was significantly identifiable, from a historical perspective for: 2 or more recorded citations for driving to endanger and/or speeding ($p < .05$); for the normal non-use of seat belts ($p < .01$), and for having a known history of one or more suicide attempts ($p < .01$). This group was also significantly different from its counterparts for having an identifiable problem with the use of alcohol ($p < .01$), the misuse of pharmaceutical drugs ($p < .05$), the known use of street drugs ($p < .01$), and for more than the experimental smoking of marijuana ($p < .01$).

One of the variables included in the initial protocol was the judgment from one or more informants regarding their global assessment of the historical patterns of alcohol use by the "most responsible" operator under investigation. The 6 level scale ranged from abstainer to alcohol abuser. The analysis of the data showed no abstainers in Group A and 22 (15%) in Group B. The light social drinkers dominated the alcohol use categories with 36 (30%) in Group A and 69 (48%) in Group B. The moderate social drinkers constituted 25 (20%) of the operators in Group A and 31 (22%) of those in Group B. At this point in the scale the direction of heavier alcohol use markedly favored Group A. The heavy social drinkers represented 36 (30%) of the subjects in Group A and only 19 (13%) of those in Group B. The sporadic binge drinkers showed 11 (9%) of the operators on Group A and 2 (1%) of those in Group B. The alcohol abusers were largely in Group A with 14 (11%) of the operators, and only 2 (1%) of the operators in Group B. As might be anticipated the difference between groups showed a significant direction favoring the heavier use of alcohol from a historic perspective and the known alcohol influence on the part of the "most responsible operator" at the time of the fatal collision ($p < .01$). The direction was even more significant when the light and moderate social drinkers were compared with the heavy social drinkers, sporadic binge drinkers and the alcohol abusers ($p < .01$). In spite of this finding it should be noted that 61 (50%) of the operators in Group A were considered to have been light or moderate social drinkers at the time of their fatal accident (Table II).

TABLE II *Historical Alcohol Use Patterns for 267 Operators*

	Group A[a]		Group B[b]		Total	
Category	N	%	N	%	N	%
Abstainers	0	0	22	15	22	8
Light Social Drinkers	36	30	69	48	105	39
Moderate Social Drinkers	25	20	31	22	56	21
Heavy Social Drinkers	36	30	19	13	55	21
Sporadic Binge Drinkers	11	9	2	1	13	5
Alcohol Abusers	14	11	2	1	16	6
TOTAL	122	100	145	100	267	100

[a] Focal alcohol involvement operators

[b] No focal alcohol involvement

It is of interest to note that the 2 groups of motor vehicle operators did not differ significantly in their age distributions. There was a slight trend showing that the

Group A operators were somewhat younger ($\bar{x}=30$ years) than the operators in Group B ($\bar{x}=33$ years) but this difference did not prove to be statistically significant. When the variable of age was applied to the historical patterns of alcohol use the findings revealed that the abstainers and alcohol abusers were considerably, though non-significantly, older than the others. The youngest group were the heavy social drinkers with a mean age of 29 years, followed by the light social drinkers with a mean age of 30 years. The moderate social drinkers showed a mean age of 31 years and the sporadic binge drinkers a mean age of 34 years. The abstainers and the alcohol abusers presented a mean age of 40 years. The non-significant findings were undoubtedly related to the wide variance of the number of subjects in the 6 alcohol use categories.

CHANGING PATTERNS OF DRUG USE

Before presenting the findings from the Boston study regarding the historical and focal use of pharmaceuticals, street drugs and marijuana it is appropriate to give a clinical overview of the changing patterns of all drug use in the greater Boston area during the period of field investigation. Throughout the 30 months of data collection the primary drug accepted for use by the Boston population was that of commercial alcoholic beverages. During 1972 and 1973 alcohol use for the teen, twenty and thirty decades shifted from harder alcoholic beverages to the drinking of wine with the emergence of the smoking of marijuana from the student population into the professional communities. Marijuana use has continued on the increase in the larger population with the growing reluctance of legal officials to prosecute the individual user for personal possession. The social smoking of marijuana has become quite acceptable and the age range of smokers has expanded progressively into the twenty, thirty and forty decades. The use of pharmaceuticals does not appear to have undergone any marked change. On the other hand, there has been a pattern of rapid evolution in the use of street drugs. During the early months of the research it was quite fashionable for the teenagers and persons in their early twenties to experiment with any and all of the available street drugs with little regard to the particular drug or its alleged strength. Suburban "fruit cocktail" parties were observed where a bowl containing whatever street drugs were available was passed among the participants so that each user could experiment with several different drugs at one time. During this period the crisis intervention centers and local hospitals were virtually flooded with overdose patients. Within this same time span the use of heroin expanded beyond the Black communities and out into the White, middle class, suburbs with an increasing number of heroin overdose patients having been seen at all of the greater Boston hospitals and the local mortuaries. In late 1972 this pattern of use quickly changed and the younger population began using particular, preferred drugs with an increase in the use of street barbiturates, a marked decrease in the use of heroin and the disappearance of the suburban "fruit cocktail." Congruent with this decrease in the secularized, intense use of any and all drugs came a wider use of particular drugs for particular occasions. The age range expanded into the late twenties and thirties and the use of street drugs moved from the field of experimentation into the areas of preferred use for particular occasions. Barbiturate use continued to increase and was joined by other 'downers' namely methaqualone. Hallucinogens were taken in smaller doses so that the user might be able to interact socially while 'tripping'. In 1973 alcohol began to assume its historic position of prominence and a growing number of people were observed to use only alcohol and marijuana. Older teenagers have returned to the "beer parties" of the 1940s with modifications for the companion smoking of marijuana. The users of street drugs have developed into what the Boston team has observed to be 7 somewhat distinctive communities including: individuals who use 'downers' namely barbiturates or methaqualone, with some regularity, most frequently in combination with alcohol; people who use hallucinogens in a social setting, as opposed to the user of the 1960s who used hallucinogens as a means of entry into personal or spiritual encounter; the amphetamine user; a decreasing number of heroin users; the elitist user of cocaine; and, the continuing communities of experimenters and chronic users.

Marijuana Use Amongst the Operators

Let us now look into the findings of the Boston study regarding the historical patterns and focal accident use of marijuana. A wide variety of approaches were used by the psychosocial interviewers to collect the data necessary to be able to score the marijuana items. Because it was upon occasion difficult to differentiate between the gradations of marijuana use for a particular individual the interviewers were very conservative in the recording of the information. In the few cases where the informants were reluctant to answer such questions the data were scored negatively. The findings showed that 146 (55%) of the total sample of "most responsible" operators either had never smoked marijuana or had only smoked it once or twice during the year prior to the accident. On the other hand, 121 (45%) were known to have smoked with some frequency. Of the operators in Group A (focal alcohol involvement) 56 (46%) were judged to have been either abstainers or experimenters with marijuana and 66 (54%) were known to have been somewhat regular users. The proportion of users and non-users was significantly different when compared with the operators in Group B (no focal alcohol involvement) when 90 (62%) of these subjects were judged to have been either abstainers or experimenters and 55 (38%) were evaluated to have been somewhat regular users of the drug ($p < .01$). The evaluated patterns of marijuana use during the year prior to the accident were broken down into 6 categories of smoking habits: abstainers, once or twice a year (experimental), 3 to 8 times a year, monthly, weekly, or more than weekly use. There was not only a significant difference between the abstainer and experimenter sub-sample and the others but there was also a significant difference between the 2 groups of operators as to the relative frequency of use ($t=2.934$, df 265, $p < .01$). The operators in Group A were not only more likely to have been smokers but were also likely to have been more regular smokers than the operators in Group B. An analysis of the smoking patterns for the 121 (45%) individuals judged to have been smokers with some frequency, that is, not experimenters, showed that 10 (8%) were classified as having smoked between 3 and 8 times during the previous year. An additional 20 (17%) were monthly smokers and 42 (35%) were weekly smokers, more appropriately called weekend smokers. The more than weekly users of marijuana included 49 (40%) of the operators. When a comparison was made between the smokers in Group A and the smokers in Group B there was a significant difference between groups, as mentioned above. The 3 to 8 times a year smokers included 4 (6%) of the Group A smokers and 6 (12%) of the Group B smokers. The monthly users of marijuana were represented by 8 (12%) of the Group A smokers and 12 (22%) of the Group B smokers. The weekly smokers (weekend smokers) constituted 29 (44%) of the smoking operators in Group A and only 13 (23%) of the smokers in Group B. The more than weekly smoker sample was represented by 25 (38%) of the Group A smokers and 24 (44%) of the Group B smokers. An overview of this analysis shows that the significant trend favoring heavier smokers in Group A (alcohol related accident) is found with the weekly or weekend smoker, not with the more than weekly smoker as might be anticipated (Table III and IV).

TABLE III *Patterns of Marijuana Use During Year Prior to Accident for 267 Operators*

	Group A[a]		Group B[b]		Total	
Use vs. Non-use	N	%	N	%	N	%
Abstainer/Experimenter	56	46	90	62	146	55
Smoker	66	54	55	38	121	45
TOTAL	122	100	145	100	267	100

[a] Focal alcohol involvement operators
[b] No focal alcohol involvement

TABLE IV *Marijuana Smoker Breakdown for 121 Operators (Year Prior to Accident)*

Number of times in	Group A[a]		Group B[b]		Total	
previous year	N	%	N	%	N	%
3 – 8	4	6	6	12	10	8
monthly	8	12	12	22	20	17
weekly (weekend)	29	44	13	23	42	35
more than weekly	25	38	24	44	49	40
TOTAL[c]	66	100	55	100	121	100

[a] Focal alcohol involvement operators
[b] No focal alcohol involvement
[c] $t = 2.934$, df 119, $p < .01$

An analysis for age showed that there was a significant trend in that the younger operators were far more likely to have been heavier smokers of marijuana (F 20.885, df5, $p < .01$). The mean age of the abstainers was 39 years, the experimenters 28 years, those who had smoked 3 to 8 times during the previous year 27 years, the monthly smokers 24 years, the weekly smokers 24 years and the more than weekly smokers 23 years. The total age range of the marijuana smokers in the Boston study was from 16 to 53 years.

From the total sample of 267 operators 43 (16%) were known to have been involved in the focal accident after they had been smoking marijuana. There were a number of other motor vehicle operators who refused to answer the questions related to focal marijuana use in spite of the assurances of the team that their responses would be considered in complete confidentiality and that their files were to be sanitized before processing. In addition to the 43 operators who admitted to marijuana use prior to the accident the Boston team reported another 18 (7%) for whom marijuana use was suspected but could not be confirmed. Within the group of the 43 operators under consideration 25 (58%) admitted that they had been drinking and smoking before their focal accident. Another 5 (12%) had been drinking, smoking and under the influence of some street drug when they experienced the crash, with a total of 30 (70%) of the 43 operators under the influence of alcohol and marijuana (Table V).

TABLE V *Focal Accident Marijuana Use for 267 Operators*

Focal use vs. non-use	N	%
marijuana use known	43	16
no marijuana use known	224	84[a]
TOTAL	267	100

Focal Marijuana Smokers	N	%
marijuana only	13	30
marijuana and alcohol	25	58
marijuana, alcohol and street/pharmaceuticals	5	12
TOTAL	43	100

Historic Patterns of Use for Focal Accident Users	Focal Users		All Users	
	N	%	N	%
Abstainers	0	0	127	48
1-2x (experimenters)	0	0	19	7
3-8x	2	5	10	4
monthly	8	17	20	7
weekly (weekend)	15	36	42	16
more than weekly	18	42	49	18
TOTAL	43	100	267	100

[a] Including 18 operators for whom marijuana use was suspected but could not be validated

The mean age of the marijuana involved "most responsible" operators was 22 years. This mean age was influenced by the finding that 18 (42%) of the marijuana influenced operators came from the 'more than weekly' group of marijuana users during the year prior to the accident which has a mean age of 23 years. In addition to the 18 (42%) marijuana influenced operators who came from historical patterns of more than weekly use, the findings showed that 15 (36%) were evaluated as having been weekly or weekend smokers, 8 (17%) monthly smokers and 2 (5%) less than monthly smokers.

It is of interest to note that 19 (44%) of the marijuana influenced "most responsible" operators were killed themselves in TYPE I accidents, 18 (42%) survived the accident which resulted in fatal injuries to another vehicular occupant in a TYPE II accident and 6 (14%) were "most responsible" operators in a TYPE III accident involving a pedestrian death.

Other Drug Use Amongst the Operators

The use of street or pharmaceutical drugs on the part of a "most responsible" operator prior to the focal crash was not as dominant as the previously reported drug influences. This sub-sample included 22 (8%) "most responsible" operators many of whom were also influenced by alcohol or marijuana. The barbiturate users were represented by 8 (36%) operators in this small sample. Only 2 operators were influenced by barbiturates alone, whereas, 4 were also under the influence of alcohol, and 2 others had been smoking and drinking as well as using this particular drug. There were only 2 (9%) operators who had been using hallucinogens, both in combination with alcohol and marijuana. A total of 4 (18%) had 'mainlined' heroin with 2 of these operators also having consumed an alcoholic beverage. One additional operator had been taking methadone and alcohol. Other drug use in this sample included: 2 operators with amphetamines, 2 with methaqualone, and 2 with antihistamines all in combination with alcohol and/or marijuana. One other driver had been taking Percodan and alcohol (Table V).

Some variety of drug involvement was evidenced for 139 (52%) of the 267 "most responsible" operators. The following patterns were observed for these 139 subjects: alcohol only, 79 (57%); marijuana only, 13 (9%); street/pharmaceutical drugs only, 4 (3%); alcohol and marijuana, 25 (18%); alcohol and street/pharmaceutical drugs, 13 (9%); and alcohol, marijuana, and street/pharmaceutical drugs, 5 (4%), (Table VI).

TABLE VI *Focal Accident Street/Pharmaceutical Drug (S/PD), Marijuana and Alcohol Use for 267 Operators*

Focal S/PD Breakdown: Total n=22 (8% of 267)

Barbiturates: n=8 (36%)
  2 alone
  4 with alcohol
  2 with alcohol and marijuana

Hallucinogens: n=2 (9%)
  both with alcohol

Heroin: n=4 (18%)
  2 alone
  2 with alcohol

Methadone: n=1 (5%)
  with alcohol

Amphetamines: n=2 (9%)
  1 with alcohol
  1 with alcohol and marijuana

Methaqualone: n=2 (9%)
  both with alcohol

Antihistamines: n=2 (9%)
  both with alcohol

Percodan: n=1 (5%)
  with alcohol

Alcohol, Marijuana and S/PDs Summary for Focal Accident Involvement: Total n=139 (52% of 267)

	n	%
Alcohol only	79	57
Marijuana only	13	9
S/PD only	4	3
Alcohol and marijuana	25	18
Alcohol and S/PDs	13	9
Marijuana and S/PDs	0	0
Alcohol, marijuana and S/PDs	5	4

During the time span of the Boston research fatal motor vehicle accidents have represented from 37% to 60% of the monthly case intake for the research team. There was a notable, though non-significant drop in alcohol related fatalities between January and August 1973 in the team's area of responsibility. This drop did not continue to maintain itself, however, and a steady increase in the number of alcohol related fatal accidents was observed from September 1973 until the close of the field investigation in February 1974. The fatal accidents with known marijuana use on the part of the "most responsible" operator have increased throughout the 30 months with 51% (22) of these cases having occurred during the last 10 months of the investigation. It should be noted that although these trends appear to be of interest there is not enough data to decide on their significance (Table VII).

TABLE VII *Total Breakdown for All 267 Motor Vehicle Operators with Respect to Alcohol and Marijuana Involvement in the Focal Accident by Four Month Categories*

	Sept. 1974 - Dec. 1971	Jan. 1972 - April 1972	May 1972 - Aug. 1972	Sept. 1972 - Dec. 1972
Group A[a]	4 (44%)	14 (60%)	9 (53%)	25 (48%)
Group B[b]	5 (56%)	9 (40%)	8 (47%)	27 (52%)
Total	9	23	17	52
Operator with Marijuana use[c]	1 (11%)	3 (13%)	2 (12%)	9 17%)
	Jan. 1973 - April 1973	May 1973 - Aug. 1973	Sept. 1973 - Dec. 1973	Jan. 1974 - Feb. 1974
Group A[a]	19 (37%)	19 (39%)	23 (47%)	9 (56%)
Group B[b]	33 (63%)	30 (61%)	26 (53%)	7 (44%)
Total	52	49	49	16
Operators with[c] Marijuana use	6 (12%)	8 (16%)	11 (22%)	3 (19%)

[a] Group A constituted the "most responsible" operators judged to have been alcohol influenced at the time of the focal accident (n=122).

[b] Group B were those operators without alcohol influence at the time of the focal accident (n-145

[c] The marijuana involved operators are without respect to alcohol use.

SUMMARY AND CONCLUSION

During the past 30 months the Boston research team has investigated 300 motor vehicle accidents involving a personal fatality in the greater metropolitan area with the principle focus of attention being upon the historical and focal human factor variables associated with the operator of the vehicle judged to have been "most responsible" for the crash. Both deceased and surviving operators were investigated. Some of the significant results for 267 of these operators were discussed. These results have shown that

39 (52%) of the "most responsible" operators were known to have been under the nfluence of some drug at the time of the focal collision. The overlapping drug cateories have included: 122 (46%) of the operators influenced to some degree by alcool, 43 (16%) of the operators known to have been smoking marijuana and another 22 8%) who had been using some street or pharmaceutical drug. The operators known to ave been using some combination of these drugs included 43 (16%) of these subjects nder consideration.

The alcohol influenced operator was identifiable from his non-drinking counterart from a historical perspective. The items in the *Risk Taking Behavior Scale*, varialles associated with antisocial behaviors and problems correlated with previous social rrors resulting from alcohol use distinguished him from the others. He was also more kely to have been a user of other intoxicants, namely marijuana and street drugs. A umber of other human factor variables differentiated the non-drinking subjects.

The findings show that the drinking operator likely to become involved in a fatal rash as the "most responsible" operator can be identified in advance. If this is the ase, the primary questions facing interested officials today are: "How can he be rawn from the general population?" and "How can he be re-oriented in his life style o that his potential element of risk can be substantially reduced?" It is the opinion of he Boston team that this very particular task should not be delegated to law enforcenent officials but rather given over to psycho-social professionals whose research and linical skills have prepared them for such an effort. Apprehension and prosecution fter the fact do not appear to be the means of controlling highway carnage. Instead he potentially risky motor vehicle operator should be sought out, re-educated and, if ecessary, rehabilitated as quickly as he can be identified.

Alcohol, Drugs, and Driving: Relative Priorities for Basic and Applied Research

M. W. Perrine[1,2]

Any consideration of research priorities is constrained by the very extent of knowledge at the moment. More specifically, it is difficult enough to attempt to establish priorities for investigating topics we *know* that we don't know much about (the so-called "known unknown"), but it is logically impossible to do so for those topics about which we know absolutely nothing (the so-called "unknown unknowns"). Thus, it would seem highly desirable to sketch the limits of present knowledge as a basis for considering research priorities in the problem areas of alcohol and drugs in relation to highway safety.

Any attempt to assess the status of current knowledge in a discipline is necessarily constrained by the relative state of the art at the moment. If the field is new, uncomplex, and clearly delineated, then several leading experts should be capable of reviewing and reaching consensus in a relatively brief time. By contrast, if the field has a long history, is multi-faceted and multi-disciplinary, and does not have clearly defined limits, then a task force of many leading experts would be required for the review, but they might be incapable of achieving consensus because of the enormous complexities of the problems, differences in orientation and subspecialities, etc. Alcohol and highway safety is a problem area which lies on the continuum somewhere between these two extreme points; it might be characterized as being relatively new as a recognized problem area, extremely complex and multi-disciplinary, and very amorphous in terms of delineation.

In October 1972, the National Highway Traffic Safety Administration (NHTSA) sponsored the Vermont Symposium on Alcohol, Drugs, and Driving which had three specific aims: to assess the status of present knowledge and to consider relative priorities for both basic and applied research in those areas germane to its theme.

---

[1] Project ABETS: Laboratory for Alcohol and Drug Studies, Department of Psychology, University of Vermont, Burlington, Vermont.

[2] The present paper is based upon a much more extensive version (13) which appears as a chapter in the final report and proceedings of the Vermont Symposium on Alcohol, Drugs, and Driving (12). This Symposium was conducted from October 13-15, 1972, and was co-hosted by the Psychological Research Foundation of Vermont and by Project ABETS of the University of Vermont. The project was supported by the National Highway Traffic Safety Administration under Contract DOT-HS-25-2-489. The project director was M. W. Perrine. The opinions, findings, and conclusions expressed in this publication are those of the writer and not necessarily those of any of the above organizations.

BACKGROUND

Alcohol and Highway Safety

As a research area, alcohol and highway safety is approximately 40 years old. The first review of the problem was presented in 1933 (9). Despite a number of articles, reports, and international conferences and congresses during the subsequent thirty years, the first major reviews of the area have only appeared during the late 1960s. Thus, as recently as 1967, it was possible for a few leading specialists to review the whole body of literature in the area and publish a comprehensive, definitive assessment of the status of current knowledge at that time (*Alcohol and Highway Safety*, 1968; A Report to the Congress from the Secretary of Transportation). At approximately the same time, a similar but more technical review was prepared by a larger group of leading specialists representing a broader spectrum of disciplines (*Alcohol and the Impaired Driver*, 1968; A manual on the medicolegal aspects of chemical tests for intoxication). A less comprehensive review, but one which included more of the European literature, was prepared by specialists in the Netherlands at the same time as the two American reviews (2).

These three reviews clearly reflect the Zeitgeist of the mid-sixties, a point in time at which the persistent efforts of a relatively small number of individuals and organizations culminated in official action being taken on the drinking-and-driving problem, e.g., the 1966 Highway Safety Act in the United States and the 1967 Road Safety Act in Great Britain. All three reviews represented independent attempts by different groups of individuals to assess the status of knowledge at that particular point in time by pulling the information together from the limited number of very widely scattered sources. All three publications were doubtless written in response to the same need, namely, to fill the gap caused by the absence of any single review and assessment of the field.

Since the mid-sixties, the body of literature concerning the role of alcohol in highway safety has expanded enormously, yet no comprehensive assessment of current knowledge was published until late in 1973. (The Vermont Symposium on Alcohol, Drugs, and Driving; Special Issue of *Journal of Safety Research,* September 1973.) The complete report of the Vermont Symposium was published by Perrine early in 1974 (12). The Vermont Symposium originated as a response to a similar need, namely, to fill the gap caused by the lack of any comprehensive review since the late 1960s; bit in addition, the status of current knowledge was evaluated and relative priorities for research were considered by means of rating procedures.

The writer wishes to express great appreciation to his colleagues who served as chairman reviewers for the Symposium and who assisted in the preparation of portions of the more extensive version of this rating study (13): Drs. Herbert Barry, III; Gerald J. Driessen; M. Stephen Huntley, Jr.; Paul M. Hurst; Herbert Moskowitz; and Reginald G. Smart. We especially appreciate the efforts of our fellow participants who also struggled through the tedium and agonies of making all the decisions involved in producing the keyword ratings which are the very data for the present paper. Special recognition and gratitude is due Robert A. Lubin and Philip M. Zunder who assisted in all aspects of the rating procedures and who conducted the further analyses concerning the influence of expertise on rating-scale usage patterns (8). We are grateful to Mrs. Mary Anne Freedman for the programming and statistical analyses of the keyword ratings.

A special word of thanks is due the three federal officials who gave so generously of their time and ideas in organizing and/or in conducting the Symposium: Dr. James L. Nichols, who served as the Contract Technical Manager, and Dr. Robert B. Voas, both from the Office of Alcohol Countermeasures, NHTSA, and Dr. Albert A. Pawlowski from the National Institute of Alcohol Abuse and Alcoholism.

Only one previous study is known in which some attempt was made to rate the adequacy of current knowledge in the area of alcohol and highway safety; however, it was only a small part of a much broader survey, such that alcohol was but one of a great many factors examined. This study was sponsored by the Automobile Manufacturers Association and was conducted in 1965-66 by Arthur D. Little, Inc. who prepared a state-of-the-art review of all factors affecting traffic safety (*i.e.,* human, environmental, vehicular, loss-limiting, and regulatory and legal factors). Alcohol was treated as one of four medical factors (along with diseases, physiological impairments, and drugs and chemical agents), which in turn were listed as one of six human factors (biographical factors, driving as a skill, medical factors, personality factors, driver education, and pedestrians). All factors were rated on two dimensions: knowledge and importance. No technical details concerning the rating procedure were provided in the report, and the following description is therefore based upon inferences made from the scant bit of text which accompanies the results of the ratings as presented in Figure 2 of the A. D. Little report (7). The purpose of the ratings was stated as, "Figure 2 is intended to provide the reader with an overview of our general understanding of the state of existing knowledge on traffic safety." (7, p. 11) Concerning the two dimensions for the ratings, it was stated that:

> *By knowledge, we mean extent to which there is factual information indicating the manner and degree to which the factor contributes to the present accident loss siutation. . . The importance rating indicates our estimate of the degree to which changes in the factor in question contribute to the present overall accident and resulting loss situation. The validity of each such rating is naturally dependent upon the knowledge rating. Thus, where knowledge is rated as good, the importance rating can be considered to be a fairly accurate estimate. Where knowledge is rated as poor, the importance rating can only be our own subjective estimate.* (7, p. 11)

Knowledge of the factors was rated on five-point scales which were apparently labeled as: none or speculative, poor, fair, good, and excellent. *Importance* of the factors was rated on five-point scales, apparently labeled as: none or freak, minor, moderate, major, and critical. The number of raters was apparently somewhere between one and fourteen. In any case, the relevant results were that the A. D. Little chart "states that our knowledge on alcohol as a contributing factor is fair and that alcohol is a critical factor." (7, p. 11)

Two previous studies are known in which an attempt was made to estimate the priority of research on the role of alcohol in highway safety (3, 4, 5).[3] However, as with the A. D. Little study, the question of alcohol research priorities was but a very small part of large-scale surveys. The first attempt (3) was a project sponsored by the Insurance Institute for Highway Safety and conducted by the American Institutes for Research (AIR). (The final report has apparently never been cleared for general distribution, which probably accounts for the fact that its contents are not very well known in the field.) The purpose of the project was to prepare recommendations for a research program to investigate human-factors aspects of driving and highway safety. Of the 24 "research program modules" that were developed and evaluated, only 2 involved alcohol ("drinking and driving in a total community setting," and "interaction effects of combined alcohol/drugs/tobacco"). Although the specific results should be considered as proprietary, it can be stated that both these modules were rated as average in urgency and above average in significance. Of greater relevance for the present study, however, is the unique and imaginative approach which the AIR investigators used to aid them during the preparation of their recommendations. As one part of the project, they surveyed "Seventy-nine individuals who had demonstrated interest in highway safety research in one form or another." (3, p. 116). In response to the initial letter from AIR, "replies either in the form of letters or phone calls, or personal visits were received from about one-half of those asked" (3, p. 120). Thus, the researchers surveyed had responded more or less extensively to a fascinating, open-ended set of questions posed in the original letter from AIR. The responses were then processed by AIR staff and reduced to the 24 "research program modules", which were then rated by AIR project staff on the dimensions of significance (direct, semi-direct, and indirect), urgency, relation to other programs, and other dimensions of project relevance. The ratings produced by the AIR project staff were then submitted to a number of mini-max analyses.

---

[3] Filstead and Rossi (1) reported on a 1973 conference which was addressed to the question, "What are the critical issues and perplexing problem areas in the field of alcohol use, alcohol problems, and alcoholism?" As indicated by this focal question, the conference was apparently much more general in scope than the Vermont Symposium on Alcohol, Drugs, and Driving, and thus offered little of immediate relevance for the present topic.

A more recent attempt to estimate priority highway safety items was made as part of a large-scale survey conducted to investigate the national problem-solving system, consisting of highway safety researchers and decision makers (4, 5). The survey was conducted by the Institute for Social Research at the University of Michigan, (apparently) in 1969, and was sponsored by the National Highway Traffic Safety administration. Of principal relevance for the present study was one open-ended question which asked, "What other area, if any, *in addition* to the above deserves top priority rating?" (The previous question had included a list of ten "activities which might be supported by the safety dollar"; and requested that the respondents "please rank in order *THREE* areas which you think should be of highest priority for receiving funds in 1970.") Usable responses were obtained from 15 alcohol-research opinion leaders, 105 highway safety researchers from a national sample, 48 decision makers from an alcohol conference, and 164 decision makers from a general sample (4, p. 105). The verbatim responses concerning alcohol priorities were presented in Appendix D of the Michigan study, where they have been separated according to whether they were recommended by decision makers or by researchers and then dichotomized (within each type of respondent) into responses that recommended "research and development" approaches or "action" approaches. Simple frequency distributions were determined which showed "a tendency for researchers to see priorities more in research terms. However, for the alcohol area, this paradigm does not hold. Here more researchers seem to be agreeing with decision makers that action strategies are necessary (4, p. D-1)."

One recommendation which emanated from his analysis of the data was to "go all out on development of countermeasures for the alcohol problem (4, p. 161)." Of particular relevance, however, were the recommendations which concerned improving the linkage between and among researchers and decision makers: (a) "support annual conferences with published proceedings on critical topics," and (b) "consider the suggestions of the researchers and decision makers themselves on improving linkage between them," with "more meetings and conferences" being by far the most popular recommendation of the researchers and one of the most popular of the decision makers (4, pp. 162-163). Thus, the Vermont Symposium was inadvertently very consistent with the results and recommendations of the Michigan survey.

Other Drugs and Highway Safety

Active concern within the area of other drugs and highway safety has only developed during the last decade. Indeed, the three major reviews of this area have only appeared during the past three years (6, 10, 11). Furthermore, no previous attempt to rate extent of current knowledge or research priorities in the area of other drugs and highway safety is known.

Advantages of the Present Study

A number of refinements and advances were achieved in the present study.

1. The ratings were obtained during the actual course of a task oriented conference of leading researchers and decision makers.
2. Each set of ratings was obtained on specific clusters of topics or keywords which were germane to the extensive discussion which had immediately preceded the rating tasks themselves.
3. The particular keywords had been selected and pretested by a small group of specialists representing each of the Symposium areas before being submitted to the larger audience of participants.
4. Certain refinements of rating procedures were possible in this face-to-face group situation which would be completely impractical in a mail or telephone survey.
5. By virtue of the group situation in a remote location, it was possible to achieve virtually 100% returns from these rating tasks.

It was felt that these considerations, in addition to the high degree of specificity of the topics which were rated, should maximize the utility of the obtained results.

METHOD

Judges

The rating tasks were performed by the 35 invited participants attending the Vermont Symposium (12, Appendix E). Most of these participants were behavioral scientists from universities, research firms, and federal agencies. Prior to the first session of the symposium, each participant completed a biographical data questionnaire on which he indicated his primary involvement in terms of one of four possible categories: (a) alcohol administrator, (b) alcohol researcher, (c) drug administrator, or (d) drug researcher. Then, if significantly involved in any other area, each participant was encouraged to check any or all of the same four categories which were listed in a subsequent question. These self-classifications were later used for grouping purposes in data analyses. Also, strictly for the purposes of analysis, each participant was subsequently rated by all session chairmen as either "expert/specialist" or "non-expert/non-specialist" in terms of knowledge of the research and literature within each individual session. The titles and chairman/reviewers of each of the eight sessions are presented in Table I. These various groupings were used in the analyses and Tables presented in the full report of this rating study (13).

Procedure

The keywords to be rated at the end of each session served to identify the particular topics of relevance within the scope of that particular session (Table I). The keywords were selected prior to the symposium by the chairman of each session and were then carefully reviewed and pretested where possible by the symposium staff. A total of 176 keywords (or phrases) was used, and ranged in number from 9 to 44 per session (Table II). The rating tasks were performed during the first two days of the symposium, with 2 sessions scheduled each morning and each afternoon.[4]

TABLE I *The Eight Sessions of the Vermont Symposium on Alcohol, Drugs, and Driving, Showing the Titles, Chairmen/Reviewers, and Rated Keyword Topics*

SESSION 1: "ALCOHOL INFLUENCES UPON NEUROPHYSIOLOGICAL, NEUROMUSCULAR, AND SENSORY ACTIVITIES" . . . M. W. Perrine

Audition
Color vision
Critical flicker fusion
Manual dexterity and steadiness
Muscle strength
Nervous system, autonomic
Nervous system, central
Retinal sensitivity
Steadiness, standing (static balance)
Steadiness, walking (dynamic balance)
Time
Visual acuity, dynamic
Visual acuity, static
Visual adaptation (glare tolerance and recovery)
Visual after-effects and illusions
Visual field

SESSION 2: "ALCOHOL INFLUENCES UPON SENSORY MOTOR FUNCTIONS, VISUAL PERCEPTION, AND ATTENTION" . . . H. Moskowitz

Attention, intensive (e.g., vigilance)
Attention, selective and divided
Depth perception
Ocularmotor activities (e.g., coordination and control)
Perceptual constancies (e.g., size, shape, color, brightness, etc.)
Perceptual suggestion (e.g., field dependence, autokinetic effects, etc.)
Reaction time, simple
Sensory motor coordination (other than tracking)
Time perception
Tracking (pursuit and compensatory)
Visual discrimination
Visual recognition and identification
Visual search
Visual signal detection

SESSION 3: "MOTIVATIONAL AND COGNITIVE EFFECTS OF ALCOHOL" . . . H. Barry, III

Decision making (willingness to accept a subjectively perceived degree of risk)
Emotion and mood
Learning (e.g., acquisition rate, state-dependency, etc.)
Memory, long-term
Memory, short-term
Motivation
Problem solving
Risk taking (objective hazard)
Verbal performance

---

[4] In order to provide data in time for presentation during the session summaries on the morning of the third day, a remote terminal was installed at Sugarbush Inn which enabled us to use the University of Vermont Computer Center for the preliminary analyses. Accordingly, the Symposium staff diligently began reducing and entering the rating data as soon as available after each session. In view of the large number of entries and the relatively slow output of the terminal, several very loyal staff members worked through the nights to meet the scheduled deadline.

SESSION 4: "ALCOHOL INFLUENCES UPON CLOSED-COURSE DRIVING PERFORMANCE" . . . S. Huntley

Control-response accuracy (in terms of the precision of single control movements)
Control-response time (choice reaction time)
Control-use coordination (e.g., as measured by gear clashes)
Control-use in emergency situations
Control-use patterns (e.g., individual profiles as reflected by control-position spectral density functions)
Decision making
Depth perception
Driving-task analysis (including modeling)
Effects of alcohol in combination with other stressors (e.g., fatigue)
Individual differences (e.g., driving experience)
Lateral tracking accuracy
Risk taking
Speed adaptation
Time-sharing (divided attention)
Track configuration
Velocity estimation
Vigilance
Visual acuity, dynamic
Visual field
Visual recognition and discrimination
Visual search
Visual signal detection

SESSION 5: "EPIDEMIOLOGICAL ASPECTS OF ALCOHOL IN DRIVER CRASHES AND CITATIONS" . . . P. M. Hurst

Alcohol consumption pattern
Alcohol consumption site
Alcohol consumption time (e.g., day of week, time of day, etc.)
Alcohol purchase site
Biographical variables
Cause of crash as a function of severity
Characteristics of passengers
Drinking antecedents (e.g., psychological stress, family conflicts, job loss, etc.)
Driving history
Motives in alcohol involved fatal crashes (e.g., suicidal)
Post crash medical treatment
Seat belt availability and use as a function of BAC
Time of crash
Tolerance to alcohol, long-term
Tolerance to alcohol, short-term
Tolerance to combination of alcohol and drugs

SESSION 6: "USE OF PSYCHOACTIVE AND HALLUCINOGENIC DRUGS IN RELATION TO DRIVING RISK" . . . R. G. Smart

Countermeasures – Legal actions: fines (varying amounts)
Countermeausres – Legal actions: forced labour
Countermeasures – Legal actions: forced treatment (e.g., driver training, therapy, etc.)
Countermeasures – Legal actions: imprisonment (varying periods)
Countermeasures – Legal actions: license suspensions & revocations (varying periods)
Countermeasures – Legal actions: mandatory chemical tests
Countermeasures – Legal actions: presentence investigation (recoding previous alcohol or drug related offenses)
Countermeasures – Legal actions: vehicle impoundment
Countermeasures – Public education: drug effects on the individual
Countermeasures – Public education: drug problems on the highway
Hallucinogenic drugs: accident histories of heavy users and dependent users
Hallucinogenic drugs: extent of use among drivers and pedestrians
Hallucinogenic drugs: risk contribution to accidents
Opiate drugs: accident histories of heavy users and dependent users
Opiate drugs: extent of use among drivers and pedestrians
Opiate drugs: risk contribution to accidents
Psychoactive drugs: accident histories of heavy users and dependent users
Psychoactive drugs: extent of use among drivers and pedestrians
Psychoactive drugs: risk contribution to accidents

SESSION 7 "DRUG INFLUENCES UPON DRIVING-RELATED BEHAVIOR: LABORATORY SIMULATOR, AND CLOSED-COURSE STUDIES" . . . J. A. Carpenter

Attention, intensive (e.g., vigilance)
Attention, selective and divided
Audition
Color vision
Critical flicker fusion
Decision making
Depth perception
Emotion and mood
Learning (e.g., acquisition rate, state-dependency, etc.)
Manual dexterity and steadiness
Memory, long-term
Memory, short-term
Motivation
Muscle strength
Nervous system, autonomic
Nervous system, central
Ocular motor activities (e.g., coordination and control)
Perceptual constancies (e.g., size, shape, color, brightness, etc.)
Perceptual suggestion (e.g., field-dependence, autokinetic effects, etc.)
Problem solving
Reaction time, choice
Reaction time, simple
Retinal sensitivity
Risk taking
Sensory motor coordination (other than tracking)
Steadiness, dynamic (dynamic balance)
Steadiness, static (static balance)
Time perception
Tracking (pursuit and compensatory)
Verbal performance
Visual acuity, dynamic
Visual acuity, static
Visual adaptation (glare tolerance and recovery)
Visual after-effects and illusions
Visual discrimination
Visual field
Visual recognition and identification
Visual search
Visual signal detection

SESSION 8: "ALCOHOL COUNTERMEASURES: SOLID ROCK AND SHIFTING SAND" . . . G. Driessen & J. Bryk

Alcohol question on driver license application
Alternative transportation (e.g., mass transit, taxi, police, buddy driving, etc.)
Detection by direct observation of erratic behavior (driving or walking)
Detection by interagency exchange of alcohol offense information
Detection by physiological tests to diagnose problem drinkers
Detection by psychological tests to diagnose problem drinkers
Enforcement by increased police surveillance on roads
Enforcement by roadblocks
Enforcement by selective police surveillance (e.g., sites of consumption, accident sites, etc.)
High school driver education
Instrumentation: anti-start devices (e.g., phystester, etc.)
Instrumentation: breath testing devices
Instrumentation: other testing devices (e.g., blood, urine, saliva, etc.)
Instrumentation: "Sniffer" devices (remote electrochemical sensing device)
Insurance actions (e.g. cancellation, rate increase, preferred rates for non-drinking, etc.)
Knowledge of effects (subject drinks of a measured 100 mg% BAC)
Legal actions: fines (varying amounts)
Legal actions: forced labor
Legal actions: forced treatment (e.g., driver training, therapy, etc.)
Legal actions: implied consent laws
Legal actions: imprisonment (varying periods)
Legal actions: license suspensions and revocations (varying periods)
Legal actions: mandatory chemical tests

Legal actions: maximum allowable BAC (100-150 mg%)
Legal actions: presentence investigation (recording previous alcohol related offenses)
Legal actions: restriction of alcohol sales (e.g., time, place, age, amount, concentration, etc.)
Legal actions: tagging of license plates
Legal actions: vehicle impoundment
Medical advisory boards
Public education of alcohol effects on the individual (e.g., effects of number and types of drinks on driving, synergistic effect of alcohol and drugs, alcohol effects in young and old drivers, safe drinking practices, etc.)
Public education of the alcohol problems on the highway
Public education of the legal alcohol limits and sanctions
Reduction of per capita consumption
Rehabilitation by Alcoholics Anonymous
Rehabilitation by behavior modification
Rehabilitation by drug therapy (e.g., tranquilizers, Antabuse, Temposil, etc.)
Rehabilitation by industrial alcohol programs
Rehabilitation by psychotherapy (individual and group)
Responsible host behavior (e.g., coffee, lodging, transportation, etc.)
Self testing for BAC
Visits to alcoholic wards
Visits to emergency rooms

TABLE II *Number of Specialists, Non-specialists, and Keywords per Session; and Rank Order Correlations between Specialists' and Non-specialists' Mean Ratings of Present Knowledge, Basic Research Priority, and Applied Research Priority*

	Number			Present Knowledge		Basic Research		Applied Research	
Session	Spec.	Non-spec.	Keywords	Rho	95% c.i.[a]	Rho	95% c.i.[a]	Rho	95% c.i.[a]
1	11	21	15	.90	.70- .98	.81	.48-.95	.89	.70 - .98
2	18	14	15	.87	.67- .97	.92	.73-.98	.82	.48 - .95
3	11	23	9	.22	–.60-+.75	.97	.78-.98	.93	.60 - .97
4	8	26	22	.83	.58- .94	.83	.58-.94	.89	.75 - .96
5	17	17	16	.84	.55- .93	.91	.75-.96	.60	.13 - .84
6	6	8	19	.34	–.16-+.65			.91	.59 - .92
7	8	6	39	.19	–.13-+.47	.82	.65-.91	.89	.63 - .89
8	16	16	44	.84	.70- .90			.62	.40 - .79

[a] The 95% confidence interval for each calculation of Spearman's rho.

The participants were seated at pre-assigned places located in alphabetic order along the outside edge of an open rectangle formed by a number of banquet tables pushed together. A coded manila envelope containing all the necessary materials was delivered to each place prior to each session. A copy of the rating instructions and an alphabetical list of the session-specific keywords was available to each participant at the beginning of each session, but the material for the rating task itself remained in the large envelopes until the end of the particular session, at which time the instructions were reviewed verbally and all participants performed the rating task concurrently.

Fifteen minutes prior to the scheduled conclusion of each session, the discussion was terminated and the rating activities started. In addition to a review of the rating mechanics each time, the following supplemental verbal instructions were also given. For the *alcohol* sessions (numbers 1, 2, 3, 4, 5, and 8), the participants were instructed to perform the rating tasks on the assumption that the research was being conducted with human subjects at medium blood alcohol concentrations which were explicitly defined as being between 50 and 100 mg/100 ml. For the *drug* sessions (numbers 6 and 7), they were instructed to perform the rating tasks on the assumption that the research was being conducted with human subjects dosed to medium levels. The participants then opened the packets which contained four smaller envelopes, each of which contained one of the four different instructions, as well as a set of all the keywords for that particular session. Each keyword was printed on a separate slip of paper along with the scale which was appropriate for that particular task. Examples of the scales are presented in Figure 1.

Task 1:

Visual field
NO KNOWLEDGE TOTAL KNOWLEDGE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Tasks 2, 3, and 4:

Visual field
LO HI
1 2 3 4 5 6 7

Figure 1 *Example of Scales*

The respondents were given the following instructions for each of the four separate rating tasks:

1. Between "no knowledge" and "total knowledge", as represented on the following scales, where do you think we are today (circle the appropriate number)?
2. Circle the number corresponding to the priority for *basic* research in terms of informational yield.
3. Circle the number corresponding to the priority for *applied* research in traffic safety.
4. Circle the number corresponding to *your own* qualifications in judging this area, a rating of 7 being comparable to the person most knowledgeable in this particular area, and a rating of 1 being comparable to a person just entering the area (e.g., a first-year student).

It should be noted that the task referred to above as Instruction 2 was omitted from Sessions 5, 6, and 8 on the assumption that basic-research ratings were not applicable.

The 4 rating tasks were performed in a random order, with the exception that Task 4 (*i.e.*, judging one's own qualifications) was always performed last in the series. Furthermore, the keyword slips in each of the smaller envelopes were in random order, and the participants were instructed not to hold any keyword aside for consideration at the end of the series, but rather to judge each keyword as it appeared in the pack.

In summary, assuming that all 35 participants rated each of the 176 keywords on the 4 different tasks (but omitting the 79 keywords from the basic-research ratings not required in Sessions 5, 6, and 8), the total number of ratings obtained at the Vermont Symposium would be 21, 875.

RESULTS

Means, medians, and standard deviations were calculated for each keyword using each of the following different groupings of participants: (a) all participants together, (b) grouped by area of activity, *i.e.*, either alcohol (whether administration or research) or drug (whether administration or research), and (c) grouped on the basis of the chairmen's ratings of each participant as being "expert/specialist" or "non-expert/non-specialist." With the exception of the first grouping of all participants, only the data from those participants for whom the general topic of the session was deemed relevant were included in the analysis of that particular session. For example, in Sessions 6 and 7, the ratings of individuals who had classified themselves as "alcohol administration" or "alcohol research" and had not indicated even secondary involvement in drug administration or research were excluded from the analyses. However, the present report is limited to those analyses in which the participants were grouped as specialist or non-specialist on the basis of the combined ratings of the session chairman.

Rationale for Constructing an Overview of Ratings

In an attempt to consolidate the most important results from each session, a comprehensive overview of all the keyword ratings was constructed. However, some reservations must be made. A most important assumption was that the keywords within each session had been rated separately and independently as a closed set, since the judges had been specificially instructed to consider that particular set of keywords strictly in the context of that session's topic, rather than to attempt to integrate relative ratings across the various sessions. This after-the-fact integration of ratings across sessions is therefore an artificial construction, and the results must be interpreted with great caution. In fact, the only justification for attempting this synthesis is that the ratings in each of the sessions were produced by the same pool of judges.

In the process of preparing this overview, it was decided to focus on the ratings by the specialists (rather than on those produced by the entire group of participants) for several reasons, and owing to the importance of this decision, the various comparisons between specialists' and non-specialists' ratings are summarized below in the next subsection. Although a high level of agreement was found between the ratings of the non-specialists and the specialists, the latter showed finer and more consistent differentiations. As a group, the specialists typically showed less variance, that is, more agreement or consensus among themselves than did the non-specialists (especially at the high and the low ends of the scale). Furthermore, the individual participants designated as "specialist" for a given session were selected on the assumption that they were relatively more knowledgeable in that particular area than were those participants designated as "non-specialists".

It was also decided to focus on the two sets of research priority ratings, with a view more toward the future than toward the status of present knowledge. In order to provide a simple and consistent overview across sessions, the three highest rated keywords from each session were selected and are presented in separate Tables according

Comparisons of Ratings by Specialists and Non-Specialists

One obvious question concerns the extent to which the ratings of the specialists differed from those of the non-specialists. Several different approaches to this question were undertaken. In the first, rank-order correlations between specialists' and non-specialists' mean ratings of present knowledge, basic research priority, and applied research priroity were determined for each keyword in each session. With only one exception (the extent of present knowledge ratings in Session 3), all the resulting correlations were statistically significant at the .05 level, indicating high general concordance between these two groups of participants (Table II).

In a more extensive methodological approach, the differences between the ratings of the specialists and the non-specialists were analyzed in terms of central tendency effect and usage of the extreme scale values (8). It was hypothesized that judges with relatively low confidence in the material to be rated would avoid using the extreme positions on the scale, but that as confidence increased, judges would be *less* likely to avoid the use of such extreme scale values. Accordingly, specialists who assumedly had more confidence in their judgments were expected to use the extreme values on the scale more frequently than non-specialists who assumedly had less confidence in their judgments and were thus expected to avoid the extreme scale values, which would lead to a central tendency effect or a piling up of ratings in the central portion of the scale. Such a central tendency effect might very well obscure any real differences in the judgmental data.

These analyses were deemed most appropriate for the ratings on extent of present knowledge, for which relative expertise was felt to be the relevant variable. It was found that the alcohol specialists (Sessions 1, 2, 3, 4, 5, and 8, combined) significantly increased in usage of extreme scale values and decreased in central tendency effect relative to the alcohol non-specialists ($p < .05$).

Regarding *priorities for basic research and applied research*, evidence was found to indicate that the specialists made greater differentiations. This difference was taken to indicate that the ratings were best differentiated and most consistent when made by the specialists rather than by the non-specialists on applied rather than basic research priorities.

In summary, a sufficiently high degree of general agreement between the specialists and non-specialists was found to warrant combining their responses in order to increase the size, stability, and generalizability of the sample data. Nevertheless, the two groupings of participants did show differences on their ratings of *extent of present knowledge*, the one dimension on which they could reasonably be expected to differ by virtue of their relative expertise. Compared with the non-specialists, the alcohol specialists tended to use a wider range of the available scale values, with proportionately less use of the central portion of the scale, which was viewed as an indication of a greater willingness to differentiate and to take more extreme positions. Furthermore, the lowest values for the rank-order correlations were obtained in the comparisons of the specialists' and non-specialists' ratings for the extent of present knowledge.

Priorities for Basic Research on Alcohol

The keywords in the alcohol sessions (Session 1 through 4) which were rated by the specialists as having the highest priorities for basic research in terms of informational yield are presented in Table III. These keywords can be meaningfully organized into three general categories: (a) alcohol influences upon basic neurophysiological activities, (b) alcohol influences upon psychological processes, and (c) alcohol influences in combination with other conditions of the organism. In the first category, the two traditional divisions of the nervous system (central and autonomic) not only received high priority ratings with high agreement among the specialists, but were also rated lowest on the extent of our present knowledge.

Regarding alcohol influences upon the second category, the psychological processes can be divided into two subcategories: (a) perceptual-attentional, and (b) cognitive. The first subcategory consists of dynamic visual acuity, visual search, and attention (intensive, selective, and divided). These psychological processes are functionally interrelated and involve what has been termed "visual information processing." The second subcategory consists of risk taking and decision making, two cognitive psychological processes which are also functionally interrelated, but are concerned with the actions or behavior resulting from the visual information processing.

Regarding alcohol influences upon the third category, the other conditions of the organism can be divided into two subcategories: (a) emotion and mood, and (b) stressors other than alcohol (e.g., fatigue). The relatively high ratings for both sets of conditions doubtless stem from recognition that any 'pure' influences of alcohol can be greatly affected by the condition of the person at the moment. Other stressors, such as noise, fatigue, other drugs, and emotional upset, when combined with alcohol, can either enhance or attenuate the basic influences of alcohol. These overlays of various combinations of stressors and emotional condition were highly rated for basic research priorities, especially in studies of alcohol influences upon driving itself (Session 4).

Priorities for Basic Research on Drugs

The three highest rated keywords from Session 7 concerning drug influences upon driving-related behavior are presented in Table III. In the case of these drug ratings, the pragmatic decision to list only the three highest keywords has necessarily led to presenting a proportionately incomplete picture of the actual ratings because of the ratio of the three keywords listed to the total keywords rated in the session (*i.e.*, in Session 1, the three top keywords represent 20% of the total of 15 keywords; whereas in Session 7, the three highest keywords represent approximately 8% of the 39 keyword total). Accordingly, if the highest 20-25% of the keyword ratings (*i.e.*, the highest 10) are examined, a pattern emerges which is essentially the same as that reported for alcohol in the preceding subsection. Thus, for the sake of efficiency, only the three exceptions to that pattern for basic research on alcohol need be mentioned here.

The 10 highest rated drug keywords included all those alcohol keywords cited in the preceding subsection and listed in Table III, with the following three exceptions: (a) "Alcohol effects in combination with other stressors (fatigue)" was not included as a keyword to be rated in the drug session, (b) "dynamic visual acuity" received a mean rating at the midpoint of the drug distribution, and (c) "motivation" was the fourth highest among the drug keywords (as it was in the relevant alcohol session, but it was not listed because it did not fall within the criteria of the highest three ratings).

In summary, there was a high level of agreement between the alcohol specialists and the drug specialists concerning which aspects of behavior should be rated highest on priorities for basic research in the two respective areas.

Priorities for Applied Research on Alcohol

The keywords in the alcohol sessions (Sessions 1-5, and 8) which were rated by the specialists as having the highest priorities for applied research in highway safety are presented in Table IV. However, only those sessions concerned with *influences* of alcohol (Sessions 1-4) are considered in this subsection; Sessions 5 and 8 were concerned with epidemiologic and countermeasure aspects of the alcohol and highway safety problem, and thus are more conveniently treated below in a separate subsection.

The keywords from Sessions 1 through 4 can be meaningfully organized in the same general categories as were used above for the ratings on basic research priorities: (a) alcohol influences upon basic neurophsiological activities, (b) alcohol influences upon psychological processes, and (c) alcohol influences in combination with other conditions of the organism. As can be seen by comparing Tables III and IV, the alcohol keywords with highest ratings on *applied* research priority (Table IV) are essentially the same as those with highest ratings on *basic* research priorities (Table III), with only two differences. On the priority ratings for applied research, "autonomic nervous system" was ranked seventh in Session 1 and was replaced among the top three keywords by "visual adaptation (glare);" and in Session 4, "visual search" was ranked fourth, being replaced among the top three by "time-sharing (divided attention)." Thus, for all practical purposes, essentially the same keyword topics received the highest ratings for both basic and applied research priorities; these keywords were explicity summarized in the preceding subsection on alcohol.

Priorities for Applied Research on Drugs

As with the preceding subsection on alcohol, the keywords concerned with *influences* of drugs upon driving-related behavior (Session 7) are considered here, whereas those keywords concerned with drug epidemiologic and countermeasure activites (Session 6) are treated in the next subsection. Relative to the ratings on basic research priorities, those for applied research emphasized the more attentional and cognitive processes, namely, attention (intensive, selective, and divided) and risk taking. Thus, these ratings reflect more pragmatic concern for the information processing and action components of the problem, rather than emphasizing the basic neurophysiological activities since "central nervous system" dropped from first place for basic research priority to 13th place for applied research priority. The other keywords among the top ten concerned with drug influences were again very similar to the keywords receiving the highest ratings for applied alcohol research priorities, with the exception of motivation, sensory motor coordination, visual recognition and identification, and visual field, none of which were found among the highest alcohol keywords.

Priorities for Applied Research on Epidemiologic Aspects of Alcohol and Drugs

Comparison of the highest rated epidemiologic aspects of alcohol and driving problems (Session 5) and of drugs and driving problems (Session 6) in Table IV reveals some clear differences in orientation which doubtless reflect differences in the respective states of the art. The epidemiology of alcohol and highway safety is at a relatively much more advanced stage of investigation and knowledge than is the epidemiology of other drugs and highway safety, which is still in its infancy. Accordingly, the highest ratings for applied research on the epidemiology of drugs in highway safety were given to incidence and prevalence studies which are necessary in the exploratory stage of a new undertaking to establish the very scope of the problem. More specifically, the highest priority keywords were concerned with the "risk contribution to accidents" of both hallucinogenic and psychoactive drugs, with the "extent of use of hallucinogenic drugs among drivers and pedestrians" receiving the third highest rating. It should be noted that these three keyword topics received the three lowest ratings for the extent of present knowledge.

It was perhaps in recognition of these differences in our knowledge about the older, established menace on the highways – as opposed to the newer, potential menace – that the highest rated keyword topic in Session 5 on *epidemiologic aspects of alcohol in highway safety* concerned the interaction between alcohol and drugs (more specifically, "tolerance to combination of alcohol and drugs"). It should also be noted that this keyword topic not only received the highest priority and greatest agreement, but was also rated the very lowest on extent of present knowledge. Research conducted on this topic would necessarily involve incidence and prevalence studies, which is an additional indication of the need for exploratory research in this area.

Excluding the above consideration of alcohol and other drugs, the highest rated priorities for epidemiologic research on the drinking and driving problem concern two aspects of the problem which can only be meaningfully investigated after a firm basis of incidence and prevalence studies had been established. The two aspects are "alcohol consumption pattern" and "driving history", both of which emphasize the study of individual differences, especially in terms of those variables for which past behavior may serve as a predictor for future behavior.

In summary, the multivariate psychometric approach to the two main components of the problem – drinking and driving – received high priority ratings for applied research.

Priorities for Applied Research on Countermeasures for Alcohol and Drugs

The priority ratings for applied research on countermeasures provided still further recognition of the differences between alcohol and other drugs in terms of the state of the art. More specifically, none of the keywords concerning *drug countermeasures* was among the highest rated priorities for applied research. Despite the fact that slightly over half (10 out of 19) of the drug keywords in Session 6 were explicitly labeled as countermeasures (see Table I), none of the keywords in the top third of the priority rankings concerned countermeasures, whereas all keywords in the lowest third of priority rankings were countermeasures. One could infer from these results that more incidence and prevalence studies are necessary to define the scope of the drug and highway safety problem before any countermeasure programs can be undertaken.

Regarding *countermeasures for the drinking-and-driving problems* (Session 8), it is interesting to note that highest priority ratings for applied research were given to the very new and the very old. "Rehabilitation by behavior modification" refers to a relatively recent but promising development in psychology which could be effective in reducing the number of problem drinkers on the road. Some exploratory research using this approach has already been undertaken, and positive results could represent a very significant advance towards solving a major component of the drinking-and-driving problem.

As a countermeasure, enforcement by police surveillance represents the most to the rank order of the mean ratings on basic or applied research priorities. Thus, the list in Table III reflects the specialists' ratings of those topics which have the highest priorities for basic research in terms of potential informational yield, whereas the list in TAble IV reflects their ratings of those topics which have the highest priorities for applied research in highway safety.

TABLE III *Specialists' Ratings of Keyword Topics Having the Highest Priorities for Basic Research*

		Rank			
		Basic research priority		Present knowledge	Total keywords
Session	Keyword	Mean[a]	SD[b]	Mean[b]	N
1	Central nervous system	1	1	1	15
	Autonomic nervous system	2	6	3	15
	Dynamic visual acuity	3	2	2	15
2	Attention: selective & divided	1	1	9	15
	Visual search	2	5	3	15
	Attention: intensive	3	10	10	15
3	Risk taking	1	1	6	9
	Decision making	2	2	2	9
	Emotion and mood	3	7	9	9
4	Alc. effects in combination with other stressors (fatigue)	1	3	4	22
	Risk taking	2	1	13	22
	Visual search	3	11	19	22
7	Central nervous system	1	4	6	39
	Attention: selective & divided	2	2	20	39
	Attention: intensive	3	21	3	39

[a] High value of the statistic is set as 1.
[b] Low value of the statistic is set as 1.

Within the group of specialists, the degree of agreement concerning the rating of each topic is indicated by the magnitude of the standard deviation; therefore, its rank is also presented in Tables III and IV. It should be noted that a rank of 1 was assigned to the *lowest* standard deviation since it reflects the *highest* degree of agreement. Thus, the ideal case for high agreement on a high priority topic would be represented by a rank of 1 for both the mean and the standard deviation; this combination was found in 7 of the 13 comparisons presented in Tables III and IV. For convenience and reference, the ranks of the mean ratings for extent of present knowledge are also included for the keywords in both these Tables. In addition, the total number of keywords in each session is also included to show the extent of possible ranks within a given session (*i.e.*, in Session 1, "central nervous system" was ranked first out of 15 possible keyword positions; whereas in Session 8, "enforcement by selective police surveillance" was ranked first out of 44 possible keyword positions).

The discussions of these rankings are presented below and are separated on the basis of either basic or applied research, either alcohol or drug influences, and epidemiologic and countermeasure aspects of alcohol and drugs.

TABLE IV *Specialists' Ratings of Keyword Topics Having the Highest Priorities for Applied Research*

Session	Keyword	Rank			Total keywords
		Applied research priority		Present knowledge	
		Mean[a]	SD[b]	Mean[b]	N
1	Central nervous system	1	4	1	15
	Dynamic visual acuity	2	1	2	15
	Visual adaptation (glare)	3	3	9	15
2	Attention: selective & divided	1	1	9	15
	Visual search	2	2	3	15
	Attention: intensive	3	7	10	15
3	Risk taking	1	2	6	9
	Decision making	2	3	2	9
	Emotion and mood	3	4	9	9
4	Risk taking	1	1	13	22
	Alc. effects in combination with other stressors (fatigue)	2	2	4	22
	Attention: divided	3	5	21	22
5	Tolerance to combination of alcohol & drugs	1	1	1	16
	Alcohol consumption pattern	2	7	13	16
	Driving history	3	4	9	16
6	Hallucinogenic drugs: risk contribution to accidents	1	4	3	19
	Psychoactive drugs: risk contribution to accidents	2	3	1	19
	Hallucinogenic drugs: extent of use among drivers & pedestrians	3	8	2	19
7	Attention: selective & divided	1	4	20	39
	Attention: intensive	2	28	3	39
	Risk taking	3	10	8	39
8	Enforcement by selective police surveillance	1	1	30	44
	Rehab. by behav. modification	2	4.5	15	44
	Polic Surveillance	3	4.5	41	44

[a] High value of the statistic is set as 1.

[b] Low value of the statistic is set as 1.

traditional, most readily implemented, but least evaluated of the many possible countermeasure approaches rated in Session 8 (N = 44). The full texts of the two highly rated keyword topics were: "enforcement by selective police surveillance (e.g., site of consumption, accident sites, etc.)" and "enforcement by increased police surveillance on roads". Since both these enforcement topics were rated very high on extent of present knowledge (respectively, 30th and 41st out of the total of 44 possible keyword positions), it can be reasonably inferred that the high priority ratings on applied research represent a strong, perceived need to have this traditional and widely used countermeasure evaluated systematically.

CONCLUSIONS

These keyword ratings from the Vermont Symposium provide an educated, consensual judgment on priorities for both basic and applied research on specific aspects of highway safety. As the most quantified judgments currently available, they also represent relatively specific recommendations by this group of specialists for future research directions. However, since these keyword ratings represent forced-choice judgments on a limited pool of specific words or phrases, it has been noted that they should not be interpreted as being judgments about whole programs, whether of research or of countermeasures (12, p. iv). Furthermore, it was strongly felt that these priority ratings should never be used as a basis for drafting budgets. In fact, as one chairman aptly phrased it, "I hope that dollar signs are never attached to these mean scale values of the keyword ratings." This position was firmly endorsed by the others.

For the National Highway Traffic Safety Administration, one of the primary purposes of the Vermont Symposium was to bring specialists together who had been most actively working in research and in evaluation of countermeasure programs in order to provide assistance and stimulation for the development of long-range programs of research concerning alcohol, drugs, and driving (12, 13, 14). Despite the relatively brief period of elapsed time since publication of the proceedings of the Vermont Symposium, there have already been indications that the recommended priorities for highway safety research have been valuable for program planning.

SUMMARY

Any consideration of research priorities is constrained by the very extent of knowledge at the moment. In turn, any attempt to determine the extent of present knowledge in the field is necessarily constrained by the state of the art at the moment. In October 1972, the National Highway Traffic Safety Administration sponsored the Vermont Symposium on Alcohol, Drugs, and Driving which was designed to address two general questions: "What do we know now?" and "What should we know?"

As a research area, alcohol and highway safety is approximately 40 years old, but the first major reviews have only appeared during the past six years. Although the body of literature concerning the role of alcohol in highway safety has expanded enormously since the mid-sixties, no recent assessment of our current knowledge is known to have been published.

Only one previous study is known in which some attempt was made to rate the adequacy of current knowledge in the area of alcohol in highway safety; however, alcohol was but one of a great many factors examined (7). It was concluded "that our knowledge on alcohol as a contributing factor is fair and that alcohol is a critical factor" (7, p. 11).

Two previous studies are known in which an attempt was made to estimate the priority for research on the role of alcohol in highway safety (3, 4, 5). In both studies, however, the question of alcohol research priorities represented but a very small part of large-scale surveys. In the first study (3), "drinking and drinking and driving in a total community setting" was rated as average in urgency and above average in significance. In the second study (4), the alcohol area was viewed by both highway safety researchers and decisions makers as an area in which action strategies are necessary. Two relevant recommendations which emanated from this study were: (a) to "go all out on development of countermeasures for the alcohol problem", and (b) to "support annual conferences with published proceedings on critical topics" (4, pp. 161-163).

Regarding other drugs and highway safety, active concern with this area of research activity has developed only during the last decade. Indeed, the three major reviews of this area have appeared only within the past three years (6, 10, 11). Furthermore, no previous attempt to rate extent of current knowledge or research priorities in the area of other drugs in highway safety is known.

The Vermont Symposium originated as a response to three interrelated needs: (a) to fill the gap caused by the lack of any comprehensive review since the late 1960s, (b) to evaluate the status of our current knowledge, and (c) to rate relative priorities for basic and applied research on the role of alcohol and drugs in highway safety.

A number of methodological refinements and advances were achieved in the present study, which was conducted as part of the Vermont Symposium:

1. The ratings were obtained during the actual course of a task-oriented conference of leading researchers and decision makers.
2. Each set of ratings was obtained on specific clusters of topics or keywords germane to the extensive discussion which had immediately preceded the rating task itself.
3. The particular keywords themselves had been selected and pre-tested by a small group of specialists representing each of the Symposium areas before being submitted to the larger audience of participants.
4. Certain refinements of rating procedures were possible in this face-to-face group situation that would be completely impractical in a mail or telephone survey.
5. By virtue of the group situation in a remote location, it was possible to achieve virtually 100% returns from these rating tasks.

It was felt that these considerations, in conjunction with the high degree of specificity of the topics which were rated, should maximize the utility of the obtained results.

The 35 invited specialists at the Vermont Symposium rated 176 keyword topics on 3 dimensions of alcohol, drug, and driving problems: (a) the extent of present knowledge, (b) relative priority for basic research in terms of informational yield, and (c) relative priority for applied research in highway safety. These rating efforts required approximately 22,000 individual decisions which were subsequently analyzed and comprise the first quantified evaluations of specific aspects of these problems (13).

Regarding the priority ratings for basic research and applied research, evidence was found to indicate that the specialists made greater differentiations than the non-specialists. This difference was taken to indicate that the ratings were best differentiated and most consistent when made by the specialists rather than by the non-specialists on applied rather than basic research priorities. However, a sufficiently high degree of general agreement between the specialists and non-specialists was found to warrant combining their responses in order to increase the size, stability, and generalizability of the sample data.

The two groupings of participants did show differences on their ratings of extent of present knowledge, the one dimension on which they could reasonably be expected to differ by virtue of their relative expertise. Compared with the non-specialists, the alcohol specialists tended to use a wider range of the available scale values, with proportionately less use of the central portion of the scale, which was viewed as an indication of a greater willingness to differentiate and to take more extreme positions. Furthermore, the lowest values for the rank-order correlations were obtained in the comparisons of the specialists' and non-specialists' ratings for the extent of present knowledge.

In order to reduce the large mass of data for the present report, a comprehensive overview of all keyword ratings was constructed in an attempt to provide an after-the-fact integration of research priority ratings across the eight topical sessions of the Symposium. This overview focused on the two sets of research priority ratings, such that only the three highest rated keywords from each session were selected for consideration in the present report.

The keywords having the highest priorities for *basic alcohol research* in terms of informational yield can be meaningfully organized into three general categories: (a) alcohol influences upon basic neurophysiological activities, (b) alcohol influences upon psychological processes, and (c) alcohol influences in combination with other conditions of the organism. In the first category, the two traditional divisions of the nervous system (central and autonomic) not only received high priority ratings with high agreement among the specialists, but also were rated lowest on the extent of our present knowledge.

Regarding alcohol influences upon the second category, the psychological processes can be divided into two subcategories: (a) perceptual-attentional, and (b) cognitive. The first subcategory consists of dynamic visual acuity, visual search, and attention (intensive, selective, and divided). These psychological processes are functionally interrelated and involve what has been termed "visual information processing". The second subcategory consists of risk taking and decision making, two cognitive psychological processes which are also functionally interrelated, but are concerned with the actions or behavior resulting from the visual information processing.

Regarding alcohol influences upon the third category, the other conditions of the organism can be divided into two subcategories: (a) emotion and mood, and (b) stressors other than alcohol (e.g., fatigue). The relatively high ratings for both sets of conditions doubtless stem from recognition that any "pure" influences of alcohol can be greatly affected by the condition of the person at the moment. Stressors other than alcohol (such as noise, fatigue, other drugs, emotional upset) when combined with it can either enhance or attenuate the basic influences of alcohol. These overlays of various combinations of stressors and emotional condition were highly rated for basic research priorities, especially in studies of alcohol influences upon driving itself.

The highest priorities for *basic drug research* were essentially the same as those for alcohol. The highest priority ratings for *applied research* in highway safety were very similar to those for basic research, especially for alcohol and to a slightly lesser extent for other drugs. Thus, there was a high level of agreement between the alcohol specialists and the drug specialists concerning which aspects of behavior should be rated highest on priorities for both basic and applied research in the two respective areas.

Highest priorities for applied research on the *epidemiology of drugs* in highway safety were given to the incidence and prevalence studies necessary in the exploratory stage of investigating a new problem (specifically, risk contribution of both hallucinogenic and psychoactive drugs to accidents, and extent of hallucinogenic drug use among drivers and pedestrians). Highest priorities on *epidemiological aspects of alcohol* in highway safety were given to the interaction between alcohol and drugs, as well as to the study of individual differences, especially those variables for which past behavior can serve as a predictor of future behavior (alcohol comsumption pattern, and driving history).

Since none of the keywords concerning *drug countermeasures* received above average priority ratings, it was concluded that more incidence and prevalence studies are necessary to define the nature and scope of the drug and highway safety problem before any countermeasure programs can be undertaken. Highest priorities for *alcohol countermeasure* research were given to a very traditional approach which seemed to be in great need of systematic evaluation (enforcement by police surveillance) and to a very new and promising approach (rehabilitation by behavior modification).

It was concluded that these keyword ratings from the Vermont Symposium provide an educated, consensual judgment on priorities for basic and applied research on specific aspects of highway safety. As the most quantified judgments currently available, they also represent relatively specific recommendations by this group of specialists for future research directions. However, since these keyword ratings represent forced-choice judgments on a limited pool of specific words or phrases, it has been noted that they should not be interpreted as being judgments about whole programs, whether of research or of countermeasures (12). For NHTSA, one of the primary purposes of the Symposium was to bring specialists together who had been most actively working in research and in evaluation of countermeasure programs in order to provide assistance and stimulation for the development of long-range programs of research concerning alcohol, drugs, and driving. There have already been indications that the recommended priorities for highway safety research have indeed been valuable for program planning.

REFERENCES

1. Filstead, W. J. and Rossi, J. J., Some Suggested Priorities in the Alcohol-problems Field, *Quarterly Journal of Studies on Alcohol* 43, 1360-1363 (1973).
2. Griep. D. J., *Alcohol and Road Safety: Countermeasures and Research – A Critical Survey of the Literature.* Institute for Road Safety Research (SWOV), Voorburg, Netherlands, 1969.
3. Hahn, C. T., *Recommendations for a Research Program to Investigate the Human Factor Aspects of Driving and Highway Safety.* American Institutes for Research, Washington, D. C. 1968.
4. Havelock, R. G., *A Nation Problem-solving System: Highway Safety Researchers and Decision Makers.* Institute for Social Research, University of Michigan, Ann Arbor, Michigan, 1971.
5. Havelock, R. G., *Highway Safety Research Communication: Is There a System?* Institute for Social Research, University of Michigan, Ann Arbor, Michigan, 1973.
6. Kibrick, E. and Smart, R. G., Psychotropic Drug Use and Driving Risk: A Review and Analysis, *Journal of Safety Research* 2, 7385 (1970).
7. Little, A. D., Inc., *The State of the Art of Traffic Safety.* Cambridge, Massachusetts, 1966.

8. Lubin, R. A., Zunder, P. M. and Perrine, M. W., Influence of Expertise on Rating-Scale Usage. In *Alcohol, Drugs, and Driving*, M. W. Perrine (Ed). National Highway Traffic Safety Administration, Technical Report, DOT HS-801-096, 1974.

9. Miles, W. R., Alcohol and Motor Vehicle Drivers. In *Proceedings of the 13th Annual Meeting of the Highway Research Board*, Washington, D. C.: National Research Council, 1934.

10. Milner, G., *Drugs and Driving*. S. Karger, Basel, 1972.

11. Nichols, J. L., *Drug Use and Highway Safety: A Review of the Literature*. National Highway Traffic Safety Administration, Technical Report, DOT HS-80-580, 1971.

12. Perrine, M. W. (Ed), *Alcohol, Drugs, and Driving*. National Highway Traffic Safety Administration, Technical Report, DOT HS-801-096, 1974.

13. Perrine, M. W., Alcohol, Drugs, and Driving: Ratings of Present Knowledge and Relative Priorities for Basic and Applied Research. In *Alcohol, Drugs, and Driving*, M. W. Perrine (Ed). National Highway Traffic Safety Administration, Technical Report, DOT HS-801-096, 1974.

14. Voas, R. B., Alcohol Countermeasures and the Vermont Symposium. In *Alcohol, Drugs, and Driving*, M. W. Perrine (Ed). National Highway Traffic Safety Administration, Technical Report, DOT HS-801-096, 1974.

Human and Environmental Factors in Alcohol-Related Traffic Accidents

Gerald W. May,[1,2] and William E. Baker

One of the most shocking problems of modern society is the tragic waste of human and economic resources in automobile accidents. Every country with an automobile population suffers loss through accidents, and yet it has become such an integral part of our every day life that we are often insensitive to it. As long as our society demands the convenience and individual control of transportation which motor vehicles provide, accidents due to human error, mechanical failure or any combination of effects will continue to occur.

The earliest research clearly indicated that human error was the primary causal factor in all automobile accidents (7). This has led to an increasing awareness of the importance of providing the proper type of driving environment to facilitate proper judgment by drivers, and a more forgiving environment in case of misjudgments. It has also become increasingly clear that, as in all human factors, very subtle combinations of factors acting to stimulate the driver may provide very different reactions in individuals. The natural progression of events has recently led to the formation of multidisciplinary teams to engage in research in the fields of safety. The rationale is simply that of providing a variety of expertise in engineering, investigation and human factors to focus attention on all the facets that may be involved in an accident. The National Highway and Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation, as one of its first priorities sponsored a number of such teams across the United States, beginning in about 1968. These teams have probably provided the most complete overall accident data that have been collected, and the data are now approaching a significantly large volume to provide a data base for a variety of studies. Their contribution has been summarized by Flamboe and Lee (6).

Impairment of the driver by alcohol has been clearly identified as the single most common human causal factor (2). The statistical evidence has not been precisely quantified for a variety of reasons, but numerous studies of the role of alcohol in fatal accidents have shown that about one-half of all fatalities involve alcohol (5). The involvement of alcohol in all accidents is not as high, but is a very significant factor.

It is therefore fruitful to focus attention on alcohol-involved accidents. Many

---

[1] Program Director, New Mexico Accident Study Program, c/o Civil Engineering, University of New Mexico, Albuquerque, New Mexico 87131 U.S.A.

[2] The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the U.S. National Highway Traffic Safety Administration.

studies have singled out and defined fatally injured drivers who had been drinking (11, 12, 13). In contrast, this study will attempt to define a cross section of all alcohol accidents, including general modalities of the event. Of special interest is the profile of the alcohol-involved driver and the errors he commits in precipitating the accident. In its broadest sense, the purpose of this study is to provide a better understanding of the entire accident.

The study universe chosen for this research was Bernalillo County in the State of New Mexico. This county includes the state's largest city, Albuquerque, and about one-third of the state's total population. Table I shows the population of the county in relation to the state according to the 1970 census figures. With a population density of 270.1 persons per square mile, it is clearly the most heavily populated area in New Mexico, which has an average density of about 8.3 persons per square mile.

TABLE I *Population distribution in New Mexico*

Place	Population	Area	Density
Bernalillo County	315,774	1,169 Square Miles	8.35/Square Mile
New Mexico	1,016,000	121,666 Square Miles	270.1/Square Mile

The population of the county was 315,774 in 1970, and was estimated at 351,800 in June, 1973 (9). About 77% of the population lives within the city limits of Albuquerque, with the rest living mainly in the Rio Grande Valley north and south of the city within about 20 miles. Table II shows a distribution of groups within the population (3).

TABLE II *Distribution of Population*

Group	Albuquerque		Bernalillo County	
	N	%	N	%
Persons of Spanish Surname or Language	85,032	34.9	123,814	39
Other White	148,122	60.8	176,969	56.3
Negro	5,425	2.2	6,689	2.1
American Indian	3,351	1.4	5,839	1.8
Other	1,821	0.7	2,463	0.8
TOTAL	243,751	100.0	315,774	100.0

The 50th percentile of age is about 23 years in the county, and this figure changes very little for the city. The mean family income for the county is $10,370, with a per capita amount of $2,704. Roughly 13% of all families are regarded to be below the poverty level. The comparable state figures are $9,193 and $2,319, respectively. The mean educational level of the over 25 population is about 3.5 years of high school. Significant is the fact that only 17% have elementary schooling and 8% have more than 5 years of University training. These figures compare with the corresponding 27% and 6%, respectively, for the whole state.

The county contains all types of transportation facilities. A modern commercial airport plus a number of small private airfields serve the city, and the main east-west line of the Amtrak (formerly Santa Fe) railway passes through the city. The east-west interstate (I-40) intersects the north-south interstate (I-25) in Albuquerque. The highest average daily traffic (ADT) in the state occurs on an urban sector of I-25.

Of the state's 832,450 motor vehicles, 260,049 are registered in the county. Table III summarizes the types of roadways and vehicle miles of travel (VMT) in the greater Albuquerque area in 1973. This area is generally defined as the city of Albuquerque plus the adjacent heavily populated North Valley and South Valley.

TABLE III *Roadway mileage and vehicle miles of travel, Albuquerque Transportation Study Area, 1973*

Type of Highway	Mileage N	%	Avg. Daily VMT N	%
Freeway	40.60	2.4	1,232,097	22.0
Principal Arterial	130.05	7.7	1,807,282	32.3
Minor Arterial	94.32	5.6	901,172	16.1
Collector	118.46	7.0	579,069	10.3
Frontage Road	15.98	0.9	47,805	0.9
Local Streets	1,294.17	76.4	1,033,061	18.4
TOTAL	1,693.58	100	5,600,484	100

The data in Table III are useful in defining the general study universe. Since this research deals with a subpopulation – those who are in alcohol-related accidents – it is of interest to relate some information about the drinking population. The Albuquerque Alcohol Traffic Safety Program (ATSP), sponsored by the NHTSA on an operational basis between 1971 and 1974, has performed a number of surveys to obtain baseline data (1). Both home and roadside (driver) surveys have been used, and their 1972 results are shown in Table IV. It is not possible to distinguish the city from the county population since the data are not sufficiently discriminating.

TABLE IV *Use of alcohol in Albuquerque*

	Roadside	Home
Yes	87.2%	76.0%
No	12.8%	21.4%
Used to	–	2.6%

The figures indicating alcohol use are substantially higher than the most recent Gallup poll figures which indicate that 68% of all Americans use alcohol. However, data show that alcohol consumption in the Mountain States is generally somewhat above average (4). Local surveys also show that 60% of drivers and 37% of all respondents drank beer as a preference.

Of great significance is the extremely high percentage of drivers that had been drinking or were intoxicated. The ATSP Roadside Survey in 1974 of about 1,000 drivers showed that almost half of the drivers surveyed in early morning hours had been drinking (Figure 1). Even more significantly, 14% were legally intoxicated at that time (BAC ⩾ 100 mg/100 ml). This is shown in Figure 2. The survey also showed that of all the drivers surveyed during all night hours, 28.2% had been drinking, and 7.1% of all drivers had a BAC of over 100 mg/100 ml.

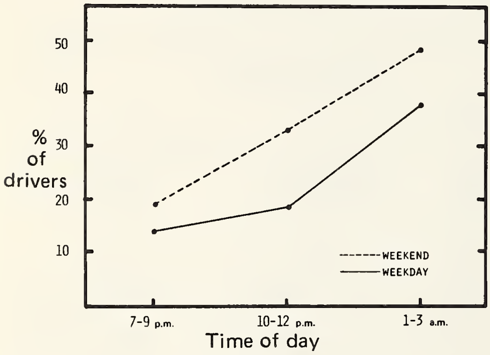


Figure 1
Percentage of drivers with BAC⩾.01%

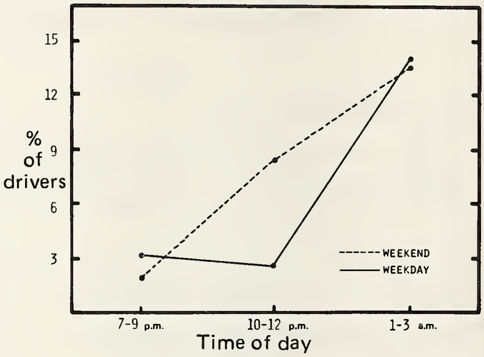


Figure 2
Percentage of drivers with BAC⩾.10%

General accident statistics are also relevant here. Historically the state of New Mexico has had a significantly higher-than-average fatality rate, compared to the rest of the country. Table V summarizes these figures for the last few years for the nation, state and county (10, 14). The fatality rate in the city has traditionally run about 40% lower than in the county.

TABLE V *Fatality rate comparisons*[a]

Year	United States	New Mexico	Bernalillo County
1970	4.88	7.63	5.76
1971	4.59	6.70	5.42
1972	4.45	6.68	5.39
1973	4.27	6.74	3.73

[a] Per 100 million vehicle miles

An additional meaningful statistic is the number of accidents and fatalities in the city and county. Table VI shows that a disproportionately large number of accidents in the county led to fatalities, undoubtedly due to the higher speeds involved. It is also of interest to note the number of alcohol-related fatalities during the last two years. The percentages show a value substantially higher than the usually quoted 50% of all fatalities that are alcohol-related. Of special interest is the fact that two-thirds of all fatalities occurring in the county outside the city limits are alcohol-involved.

TABLE VI *Accident data in city and county*

Accidents and Fatalities	Albuquerque 1972	1973	Bernalillo County (Excl. Albuquerque) 1972	1973
Accidents	15,044	14,729	2,148	2,173
Fatalities (Number)	55	39	45	43
Alcohol-related Fatalities	27	24	30	29
Percentage Alcohol-related	49%	62%	67%	67%

In summary, the data discussed above show that the study area differs from the rest of the country in a number of ways. Specifically, Alburquerque shows greater-than-average use of alcohol and occurrence of drinking and driving, and a higher proportion of heavy drinking. The population is also unique in its racial makeup, with a rich mixture of Anglo, Hispanic, and native American cultures. It is within this setting that this research was conducted over a period of two years, starting July, 1972.

RESEARCH DESIGN

In order to provide data at three different levels of intensity, this research had a multi-level design. Figure 3 shows the relative populations of each of the three study levels. Out of the total accident population of about 30,000 for two years, those of interest in this research were the ones involving alcohol. At the first level of study, data from the police records were extracted for all of the alcohol-involved accidents. These accidents were identified as the ones in which the police officer filed a report stating that at least one of the drivers had been drinking. It did not necessarily mean that the driver was cited for driving while intoxicated or was even necessarily responsible. The number of these accidents is probably greater than 2000 per year.

The second level of study was concentrated on a subpopulation of the total alcohol-involved population identified from the police records. The total number of drinking-drivers and their motor vehicles selected for study was 200. These accidents were selected randomly and studied as they occurred, although preference was given to those involving the more serious accidents with injury. There were also other practical considerations that dictated the choice of the accidents. Usually, the vehicle had to be disabled so that it could be available for study. The driver had to be available, preferably for a personal interview. Finally, if there was a choice, accidents were selected so as to provide a fairly steady flow of work for investigators. The purpose of the second

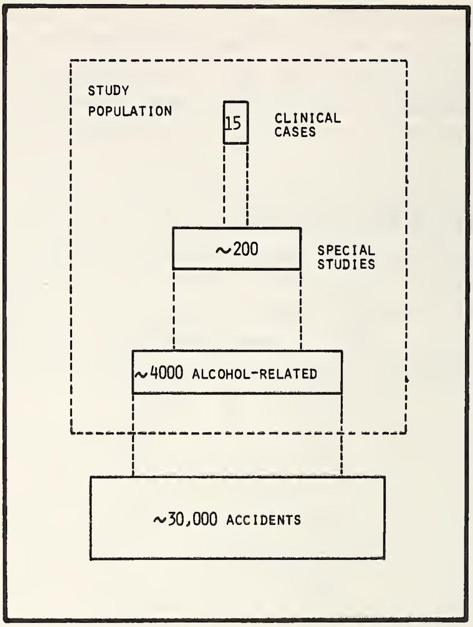


Figure 3 *3 Levels of the accident study population*

level of study was to identify and gather information on a substantial population of alcohol-involved drivers at a much more intensive level than the police investigations. The contribution of the environmental, human, and vehicle factors in the accident were examined at this level. In addition, more accurate driver profiles were developed to assist in countermeasures and rehabilitation programs and to provide a better understanding of the entire milieu in which such accidents occur.

The third level of study was restricted to a very small number of accidents picked from the population described above. These 15 accidents were treated as clinical case studies and were studied in greater depth than the preceding level. Detailed case reports in narrative form were submitted on each one, along with photographs, Collision Performance and Injury Report (CPIR) vehicle forms and other requirements of NHTSA. Along with careful analysis of vehicle and environmental factors, these cases attempted to examine the personality factors and alcohol habits of the driver. Various tests were performed to attempt to quantify these factors and habits. These cases have been useful in formulating some hypotheses for possible future testing using larger sets of data.

The results cited in this paper deal with the second-level population. This level of study is probably the most efficient one in terms of amount of data gathered and effort expended. It was designed to provide as much factual information as possible and to include a careful analysis of the causal factors. There were at least 250 pieces of data in each accident. These were gathered in the field and derived in the analysis and recorded on coded work forms suitable for later key punching and data processing.

The investigation techniques were tailored to suit the type of accident and the unique local factors that prevailed. In general, the accidents were chosen by one of two means, either on-scene or retrospectively. Some cases (especially the clinical cases) were actually investigated as they happened by a field team which monitored police radio transmissions and arrived at the scene immediately. This method provided the best quality data and included the easily-lost transient data. The team was fielded during peak accident hours, generally weekend nights.

It was not necessary to be on the scene of each accident included in the study; many were identified the next day when the police officers filed their reports. Immediately after selection of an accident, the investigators started gathering the necessary data. In general, the following steps were taken and are shown in the order of priority:

1. Site inspection, photographs and measurements.
2. Vehicle inspection, photographs (generally at salvage yard).
3. Interviews with involved drivers.
4. Obtaining medical records to determine injuries.
5. Collection of other information: – previous traffic violations, – Probation Department records, – alcohol treatment history.
6. Analysis of human, environmental and vehicle factors.
7. Determination of causal factors.

Due to the inability to complete one of the phases above, some accidents had to be abandoned. Obviously, gaining cooperation of the drivers was the major hurdle to successful completion of the case.

RESULTS

The results of the preliminary data processing are discussed below. Of the 200 accidents, 106 are involved in this analysis, and there is reason to believe that the general distributions of responses will not change substantially when all the data have been processed. The data can be organized into five general headings and the results discussed within the framework of: Identification, Environmental Data, Vehicle Data, Driver Data, and Causal Factors. Only select information will be discussed here for the sake of brevity, with special emphasis on the alcohol-involved driver.

Identification Data

Figures 4 through 7 and Table VII summarize some data regarding the general profile of alcohol-involved accidents in this study. They are generally clustered around the late night and early morning hours, and drop off after the bars close at 2:00 a.m.

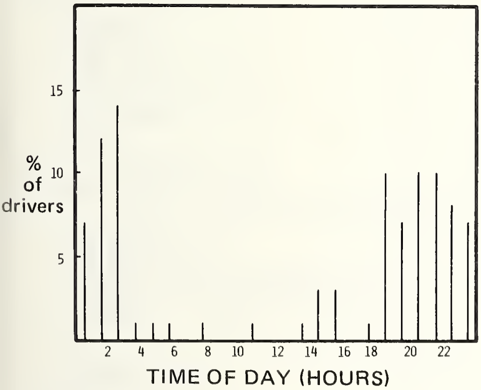


Figure 4 *Time of day*

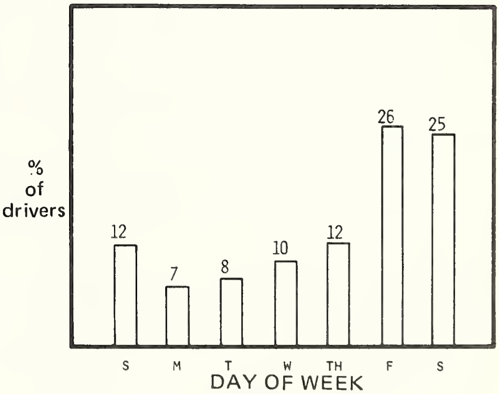


Figure 5 *Day of week*

Accidents were distributed fairly uniformly throughout the week except for a sharp increase on Fridays and Saturdays. Fifty-one per cent of all accidents occurred on those two weekend days.

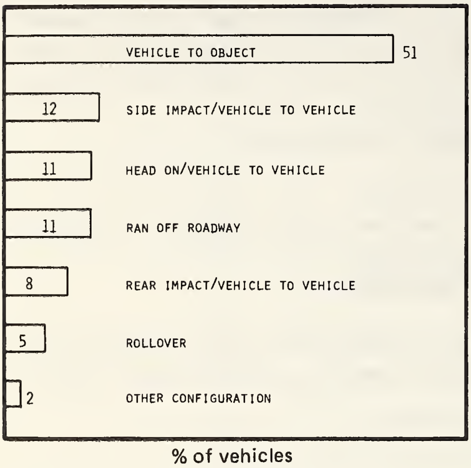


Figure 6 *Accident configuration*

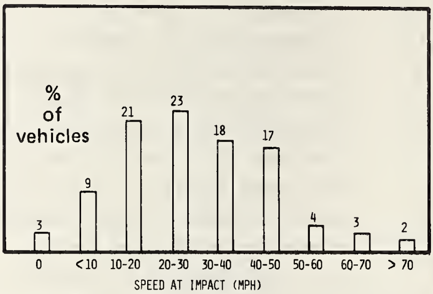


Figure 7 *Speed at impact*

TABLE VII *Identification Data (N = 106)*

DESCRIPTION

	%
Single Vehicle	68
Single Occupant	58
Two Occupants	28

OBJECTS CONTACTED

	Primary Impact %	Secondary Impact %
Other Vehicle	52	7
Pole or Tree	14	3
Fence/Wall	5	3
Rollover	7	4
Curb	5	—
Other	17	2
Nothing	—	81

ENFORCEMENT

	%
Citations/Accident	2.3
Driving While Intoxicated	72
Reckless	45
Careless	41
No Driver's Licence	19

OTHER OCCUPANTS

	%
Using Seatbelt	12
Had Been Drinking	33

Figure 6 shows the collision configuration distribution. Fifty-one per cent of all accidents involved a single vehicle striking a fixed object. A parked car with no occupants was considered a fixed object for this analysis. Side Impact, Head On, and Ran off Road accidents comprised another 34%. Table VII shows that 68% of all accidents involved a single vehicle. In comparison, less than 12% of all city accidents were single-vehicle. Fifty-eight per cent of all accidents (85% of the single-vehicle accidents) had only the driver in the car while 28% had the driver and a single passenger leaving 14% with more than two occupants. Generally, the second occupant was female. More than a third of the passengers were known to have been drinking as well. Twelve per cent of the passengers were wearing seatbelts, about the same percentage as the drivers.

Objects hit are also shown in Table VII. The high number of other vehicles struck by the accident vehicle was partially due to a disproportionate number of parked car accidents, which were coded as "Single Vehicle", "Vehicle to Object", and "Struck Other Vehicle". When a vehicle ran off the roadway and rolled, it was classified as a "Rollover", since this was the more significant factor. Nineteen per cent of the striking vehicles then continued and struck another object before coming to rest.

Figure 7 shows the distribution of speeds of vehicles at impact. These figures were derived from a careful analysis of all evidence in the case, and show that 50% of all the accidents occurred at less than 30 MPH. A similar curve showing speed before impact would be somewhat higher, since many drivers reacted by slowing when an accident was imminent.

TABLE VIII *Environmental Descriptors (N = 106)*

LOCATION	%	CONFIGURATION	%
Commercial	57	Roadway	51
Residential	35	Intersection	29
Urban Undeveloped	6	Freeway Ramps	11
Other	2	Other	3
ROADWAY TYPE	%	AMBIENCE	
Arterials	41	Dry Conditions	93%
Collectors	18	Dusk/Dawn or Dark	88%
Freeways and Ramps	22	Light/Moderate Traffic	92%
Residential	17	Average Temperature	56.6°F
Other	2		
ROAD DESCRIPTION	%	AVERAGE DAILY TRAFFIC COUNTS	%
1-2 Lanes	40		
3 or More Lanes	60	<5,000	23
38 MPH Average Speed Limit		5,000-10,000	16
		10,000-20,000	29
No Pavement Markings	23	20,000-30,000	13
Average Grade	2	>30,000	18
Horizontal Curve	24		

Environmental Data

Select environmental data are summarized in Table VIII. These data show that most of the accidents occurred in the central part of the city. Of significance is the fact that over one-half of the accidents occurred on the open roadway, away from high conflict areas such as intersections. The distribution of roadway types very closely parallels the vehicle miles of travel figures of Table II. Ambient conditions were overwhelmingly favorable, except for the fact that 88% occurred after dark or dusk. The average daily traffic count figures reinforce the fact that most accidents occurred on arterials.

Vehicle Data

Vehicle descriptors are summarized in Table IX. Much additional detailed information was gathered, but the Table shows only the general description of the vehicle and condition.

Typically, the vehicle was 7 years old, a 2-door hard-top or sedan, and had 45,000 miles on the odometer. This reading is very low for the age of the car, but the data were skewed by the fact that any mileages over 100,000 were not averaged properly in this computation.

TABLE IX *Vehicle Descriptors (N = 106)*

TYPICAL VEHICLE
1967 Model
2-Door Hardtop or Sedan
V-8 Engine
3,200 Pounds Curb Weight
45,000 Miles Odometer Reading
No Color Preference

VEHICLE CONDITION

	%
Tire Defects	11
48° Steering Wheel Freeplay (Av.)	
Brake Pedal Pressure Unsatisfactory	34
Pitted/Heavily Soiled Windshield	33
No Valid Inspection Sticker	31
Poor Exterior Condition for Mileage	24
Minor Unrepaired Exterior Damage	17
Unrepaired Previous Accident Damage	13
Repaired Previous Accident Damage	4
Exterior Decorations by Owner	15
Interior Decoration by Owner	11
Tassels, Soft Interior Decorations	8

VEHICLE DAMAGE
15 Inches Crush (Av.)
3% Fuel Leakage

The vehicle condition, on the other hand, was generally poor. Maintenance was unsatisfactory, as the figures for tires, steering, and brakes indicate. Only 42% of all vehicles were in good, undamaged pre-crash condition. Also 15% of all vehicles had exterior decorations added by the owners, and 19% had interior decorations. These ranged from chrome strips and custom paint stripes to custom shag carpeting. Eight per cent had interior embellishments consisting of soft tassels, fuzzy balls, dolls, etc.

Driver Data

The summary data for the alcohol-involved drivers are presented in Table X and Figures 8 to 13. This population was composed of 150 individuals, and specifically excluded the other drivers who were involved in the accident but had not been drinking. This latter population contained 40 more individuals. The sample size for the human data is larger than that of the other categories due to the fact that these results were available without a complete analysis of other factors. The statistics show that the alcohol-involved drivers were responsible for 94% of the accidents.

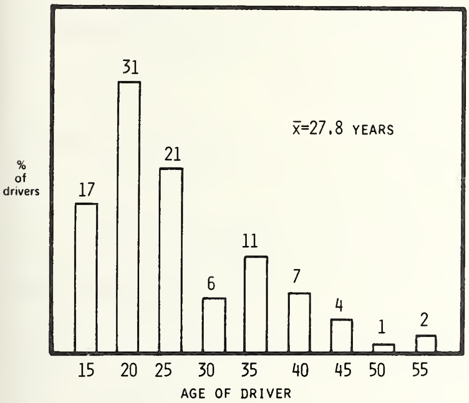


Figure 8 *Age distribution*

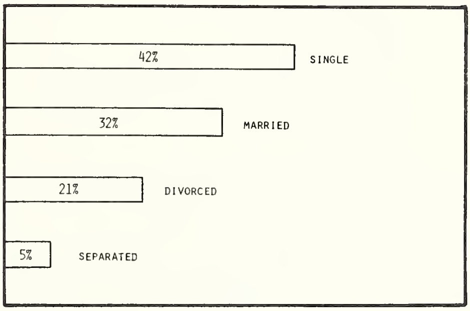


Figure 9 *Marital status*

The typical alcohol-involved driver is described in Table X. He is male (84%), 27.8 years old, 68 inches tall, and weighs 152 pounds. The age distribution is shown in Figure 8. Of interest is the fact that 48% of all drivers were 24 years old or less. This was significantly more than the 40% figure reported by the county for all accidents. The driver had an average of 4.2 siblings and was typically the third child. The population was divided as follows: Anglo Saxon and Spanish surnames or language 46% each, American Indian 7%, Negro < 1%, and Oriental < 1%. These numbers are in contrast to the distribution in Table II, which shows that 35-39% of the population is Spanish and less than 2% Indian. Figure 9 shows that only 32% of all the drivers were married and living with their spouses.

As a crude measure of the driver's social rank, the Hollingshead Two-Factor Index of Social Position (8) was calculated. This index categorizes an individual according to two measures: profession, and educational background.

This index is not completely reliable, but serves as a useful tool which is particularly easy to apply. It is of special significance to note in Figure 10 that a full 76% of this population fell within the two lowest classes (IV and V). These two classes

TABLE X *Driver Descriptors (N = 106)*

DRIVER PROFILE	%	RACE/ETHNIC BACKGROUND	%
Responsible	94	White Anglo	46
Male	84	Spanish Language or Surname	46
	$\bar{x}$	Native American	7
Years Old	27.8	Negro	<1
Inches Tall	68	Oriental	<1
Pounds Weight	152		
Siblings	4.2	VEHICLE FAMILIARITY	%
Birth Order	2.9	Greater Than 1 Year	35
Jobs in Past 5 Years	3.25	6 Months to 1 Year	21
		1 Month to 6 Months	26
DRIVING HISTORY	%	1 Week to 1 Month	7
No Driver's Licence	20	1 Day to 1 Week	4
Average Previous Moving Violations	1.78	Less Than 1 Day	7
Average Previous Accidents	1.38	TRIP DESTINATION	%
Driver Training	47	Home	69
		Friend/Relative's House	15
TRIP ORIGIN	%	Pleasure Ride	8
Friend/Relative's House	34	Other	8
Tavern/Restaurant	26		
Home	14	PSYCHOLOGICAL STRESS	%
Work	7	None Obvious	65
Other	19	Domestic Problems	17
		Financial Problems	3
TIME SINCE LAST STOP	%	Others, Combinations of Above	18
Less Than 10 Minutes	50		
More Than 10 Minutes	50	ALCOHOL USE HABITS	%
		Prefer Beer	74
SEATBELT USE	%	Drink for 2-3 Hours at a Sitting	51
Not Installed	17	Use Other Drugs While Drinking	27
Installed, Not Used	70		
Installed, Used	11	NORMAL DAYS OF DRINKING	%
Intentionally Defeated	2	Weekend	45
		Daily	22
FREQUENCY OF DRINKING	%	Variable	21
2-3 Times Per Week	24	Special Occasions	8
Daily	23	Other	4
Once/Week	19		
2-3 Times Per Month	10		
Once/Month	10		
4-5 Times Per Week	8		
Other	6		

ALCOHOL PROBLEMS	%
Admit to Alcohol Problems in Immediate Family	26
Admit to Problem Drinking	20
Admit Social Problems Due to Drinking	24
Diagnosed as Problem Drinkers	51

generally typify individuals who are in positions such as minor clerical, service workers, semi-skilled workers and manual laborers, and have the equivalent of high school education. Typically, the driver had held 3.25 jobs in the last 5 years.

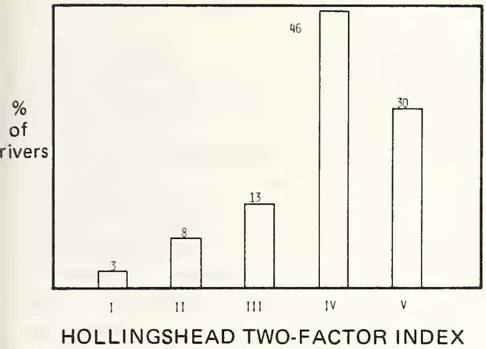


Figure 10 *Hollingshead Index Distribution*

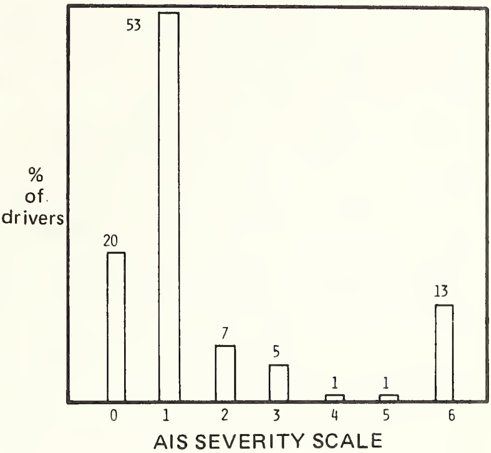


Figure 11 *Injury severity distribution*

The driving history of these drivers is interesting. Twenty per cent of them had no valid driver's license, and 60% of these (12% of the total population) had never been issued one up until the time of the accident. Typically, a driver had 1.78 previous moving traffic violations on his record and 1.38 previous accidents. Both of these figures are probably on the low side of reality, since they rely on the driver's self-admitted record and/or on state motor vehicle records that were in many cases incomplete and had been truncated to include only the last five years. Forty-seven per cent of the drivers had some sort of driver training, either at school or job-related. It is also of significance to note that 66% of all drivers had been driving the accident vehicle for less than one year and 18% for less than one month.

Typically, the alcohol-involved driver originated his trip at a friend or relative's house (34%), or tavern or restaurant (26%), and was headed home (69%). Half of the drivers had been driving less than 10 minutes since the last substantial stop. Thirty-eight per cent admitted to some psychological stress, with 17% admitting to domestic problems affecting their concentration while driving.

Figure 11 summarizes the distribution of injury severity for all the alcohol-involved drivers. Twenty per cent were uninjured, and 53% sustained minor injuries (Abbreviated Injury Scale (AIS) 1). Thirteen per cent were fatally injured (AIS 6 or more). Seatbelt usage was minimal; only 13% of the cars were equipped with seatbelts and only 11% of all drivers wore them. Two per cent had hidden the belts under the seats in an inaccessible location or had intentionally defeated their purpose by cutting them off or disconnecting the buzzer or interlock.

Data on alcohol use habits of the alcohol-involved drivers were collected from interviews with the drivers, presentence court reports, or immediate family sources. Due to the nature of the questions, some drivers felt threatened by them, so that the data were incomplete. In spite of this, information has been obtained for about 80% of the drivers to date. It must also be recognized that not all questions were answered truthfully. Table X summarizes some select data of interest. The modal responses indicate that the majority of drivers preferred beer (74%), drank 2-3 times per week, on weekends, for 2-3 hours at a time. Twenty-seven per cent of the drivers who responded admitted to using other drugs, *i.e.*, street drugs, marijuana, barbiturates, while drinking. Some of these were under the influence of drugs when involved in the focal accident, but many were not, and simply admitted to the interviewer that they often used them while drinking.

The degree of alcohol involvement is summarized for all drivers in Figure 12. The abscissa is not continuous but shows the composite sample. Twenty-six per cent had been drinking, but no blood test was taken. The distinction between 'had been drinking/intoxicated' and 'had been drinking' was based on further evidence at the scene or on officers' statements. Of this subpopulation, the majority were those who had been cited for driving while intoxicated, but refused a chemical test. Under New Mexico law, they would then face mandatory revocation of their license for one year. Since 20% of the population had no license, they often felt it advantageous to refuse and thus have no quantified documentation regarding their inebriation admitted to the court. Of the 74% who had chemical blood tests administered, the mean value was .195%. Of interest is the fact that 6% had a blood alcohol concentration in excess of 0.40%; the highest value recorded was 0.50%.

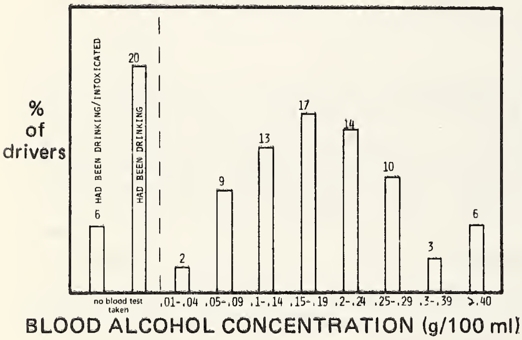


Figure 12

Blood alcohol/alcohol use distribution

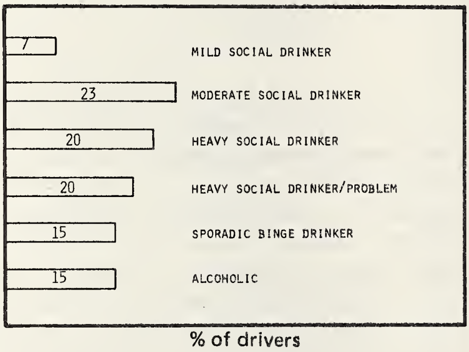


Figure 13

Clinical diagnosis of alcohol use

A significantly high proportion of drivers admitted to alcohol problems in the immediate family (26%); social and marital problems due to alcohol (24%); and their own problem drinking (20%). These and other data were synthesized to determine a diagnosis of the driver's alcohol use. Approximately 30% of the total alcohol-involved population presented such contradictory data that they were classified as "indeterminate". The remaining population is shown in Figure 13. Of very special note is the fact that 51% of the drivers were classified as problem drinkers. This latter population was divided roughly into the three categories: heavy social problem drinker, sporadic binge drinker, and alcoholic. A further 20% were defined as heavy social drinkers, but did not exhibit the history of alcohol-related social and personal problems that characterized the problem drinkers.

Causal Factors

Finally, the causal factors are summarized in Table XI and Figure 14. The entire event was carefully analyzed and the contribution of all of the factors in the accident weighed. A systematic way of rating the causal factors was developed and a composite index derived. Briefly, it retained information on the type of causal factor (human, environmental, or vehicle), the specific error or factor, the degree of alcohol involvement, and which vehicle was involved. The principal causal factor was defined as the factor judged to be primarily responsible for the occurrence of the accident, and without which it would not have occurred. A contributing causal factor was defined as a factor which contributed to accident causation, but was not in itself the precipitating event. In order to distinguish the effect of alcohol, it was not included directly as a principal or contributing causal factor since it could be regarded as being the ultimate root cause of most of the accidents. Instead, the cause was assessed independently of alcohol involvement, then a degree of probability was assigned to the dependence of the causal factor on the effects of alcohol.

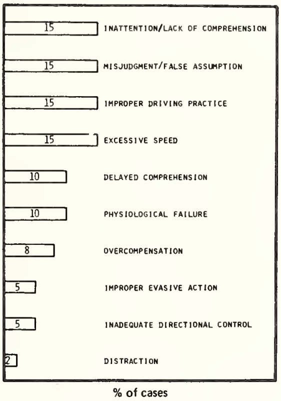


Figure 14 *Human principal causal factor distribution*

TABLE XI *Causal Factors (N = 106)*

PRINCIPAL CAUSAL FACTORS	%
Human	93
Environmental	7
Vehicle	—

CONTRIBUTING CAUSAL FACTORS	%
None	42
Human	24
Environmental	19
Vehicle	15

DEGREE OF ALCOHOL INVOLVEMENT IN HUMAN CAUSAL FACTORS

	Definite %	Probable %	Possible %
Principal Factors	47	45	8
Contributing Factors	11	78	11

Ninety three per cent of all principal causal factors were human errors, and the remaining 7% environmental faults or overloads. The final analysis of all the data will show some accidents caused by vehicle failures, but the number will be small. The specific human errors are shown in Figure 14. Inattention, misjudgment, improper driving practice, and excessive speed represented 60% of these factors. Forty-seven per cent of all of the principal human causal factors were definitely a result of alcohol impairment, while a further 45% were probably due to alcohol.

The contributing factors show a much wider spread. Forty-two per cent of all cases had no contributing factors, *i.e.* there was a single factor defined to be principal. The remaining 58% was divided into human (24%), environmental (19%), and vehicle (15%).

CONCLUSIONS

The purpose of this paper has been to present some preliminary data on a limited number of alcohol-related accidents selected from a larger population. An attempt was made not only to gather human data, but to analyze the contribution of the environment and vehicle to the accident. In addition, data on the alcohol use patterns of the drinking drivers were gathered.

The general study universe was geographically isolated. The population was composed of White Anglo Saxon, Spanish and native American segments, with deep respective cultural roots. The population appeared to use alcohol more than the rest of the United States, and appeared to mix drinking and driving to a greater degree as well. Although the fatality rate in the county was found to be lower than the national average, the state's record was much worse. The overwhelming majority of all fatal accidents were alcohol-related.

In composite as far as the present study is concerned, it appears that the alcohol-involved driver is male, young, disproportionately Spanish or native American origin, unmarried, and a manual worker. He is relatively inexperienced with his car, often has no driver's license, and is driving from a friend's to his home. He is typically impaired well beyond the legal presumptive limit when involved in the accident. His history and alcohol use patterns indicate that a majority are problem drinkers.

The accident typically involves a single driver in a single vehicle striking a fixed object on or off the roadway. It occurs late at night or early in the morning on weekend nights. The accident occurs at fairly low speed. The police typically charge the responsible alcohol driver with multiple violations.

The environmental data show that the accidents do not necessarily occur in high conflict areas, but are generally on the open urban roadway. Their location indicates that drinking-drivers probably have about the same use patterns of various types of roadways as all motorists. Environmental factors are not significant.

The vehicle driven by the alcohol-involved driver is typically old, and in a generally poor state of maintenance and repair. It is often embellished by exterior and interior decorations added by the owner.

Human error almost always precipitates the accident. The most common errors are lack of comprehension, misjudgment, improper driving and speeding. These errors are generally brought on by the effects of alcohol.

Although the general patterns above emerge clearly, it would be valuable to compare them with a valid control group. One such group is the smaller number of drivers who are involved in the same accidents, but who had not been drinking. The data are not complete and it is not within the scope of this paper to examine the differences statistically. However, preliminary examination of the data indicates that there are significant differences. The control population in this study appear to be significantly older and of a higher Hollingshead Index (8). They are predominately male (80%) and Anglo (64%). They have fewer previous violations, have valid licenses (94%), are more experienced with their vehicles and wear their seatbelts more often (30%). Most importantly, only approximately 5% can be classed as problem drinkers. These are only very preliminary figures, and much more remains to be done to compare these two populations, but the trends promise to be interesting.

It also appears that alcohol accidents are modally quite different from the general vehicle accidents. For instance, less than 12% of all accidents in Albuquerque involve only one vehicle, as opposed to 68% in the alcohol population. About 8% of all accidents are fixed object collisions, as opposed to 57% of the study population. Finally, only 67% of all drivers in accidents are male, compared to the 84% cited in this paper.

One final word of caution must be injected at this point regarding the limitation of these statistics. They are preliminary, since the complete population for this study has not been processed yet. They are selective, since the most reliable data have been presented, and null responses eliminated. However, the complete results will provide a data base for better understanding of alcohol accidents as well as hypotheses for future testing and analysis.

REFERENCES

1. *Albuquerque/Bernalillo County Alcohol Traffic Safety Program, Final Roadside Survey Report*, June 30, 1974.
2. American Medical Association, *Committee on Medicolegal Problems; Alcohol and the Impaired Driver*, American Medical Association, Chicago, Illinois, 1968.
3. Department of Commerce, Bureau of Census, *General Social and Economic Characteristics, 1970 Census of Population; Final Report,* PC (1)-C33 New Mexico, 1971.
4. Department of Health, Education, and Welfare, *Special Report to U.S. Congress on Alcohol and Health*, U.S. Government Printing Office, Dec., 1971.
5. Department of Transportation, *1968 Alcohol and Highway Safety Report*, U.S. Government Printing Office, August, 1968.
6. Flamboe, E. E. and Lee, S. N., Short Term Benefits From Field Accident Studies. *Proceedings of Sixteenth Annual Conference of the American Association for Automotive Medicine*, Chapel Hill, North Carolina, October, 1972.
7. Forbes, T. W., (Ed.), *Human Factors in Highway Traffic Safety Research*, Wiley-Interscience, New York, 1972, pp. 303-330.
8. Hollingshead, A. B., *Two Factor Index of Social Position*, New Haven, Yale University Press, 1956.
9. Middle Rio Grande Council of Governments, *Initial Overall Economic Development Program*, District 3, 1972.
10. National Safety Council, *Accident Facts* 1972.
11. Selzer, M. L., Alcoholism, Mental Illness, and Stress in the Drivers Causing Fatal Accidents. *Behavioral Science* 14, 157-163 (1969).
12. Sterling-Smith, R. S., and Fell, J. C.; Special Accident Investigation Studies; The Role of Alcohol/Drug Involvement. *Proceedings of the Sixteenth Annual Conference of the American Association for Automotive Medicine*, Chapel Hill, North Carolina, October, 1972.
13. Waller, J. A., King, E. M., Nielson, G. and Turkel, H. W., Alcohol and Other Factors in California Highway Fatalities. *Proceedings Eleventh Annual Meeting of American Association for Automotive Medicine*, 1970.
14. *1973 Traffic Accidents*: Albuquerque, Bernalillo County, Traffic Records Center, Report 67, February, 1974.

The Prevalence of Drugs in Fatally Injured Drivers

E. J. Woodhouse[1]

The National Highway Traffic Safety Administration of the United States Department of Transportation is presently sponsoring programs to determine the occurrence of drugs in both fatally injured drivers and drivers on the road. This paper presents the accomplishments and results of the initial study to determine the frequency with which various drugs are found in fatally injured drivers. Discussed below are the program goals, methodology and results.

GOALS

The goals of this program were to sample the physiological fluids of fatally injured drivers and analyze such samples for the presence of a wide range of drugs, including alcohol, sedatives, stimulants, opiates and tranquilizers. Specific objectives of the program were to develop methods for the acquisition of specimens from fatally injured drivers, to develop a scheme for the analysis of such specimens for drugs, and to implement the analysis scheme on specimens from the fatally injured drivers.

METHODOLOGY

Acquisition of Specimens

Specimens of blood, urine, bile, and alcohol swabs from the fingers and oronasal area, were collected from 710 fatally injured drivers. The blood was analyzed for drugs (including alcohol), the urine and bile for drugs (excluding alcohol), and the alcohol swabs for traces of marihuana. Specimens were collected from drivers who were dead on arrival at the hospital. Collection of the specimens was achieved through the cooperation of local medical examiners and coroners with the assistance of Alcohol Safety Action Program (ASAP) Area Directors. Kits for the collection of specimens consisted of plastic tubes for urine and bile, vacutainers for blood, and a set of three swabs marked "left hand", "right hand", and "mouth", with a small vial of alcohol for swabbing purposes. A request for data on the crash victim and circumstances was also mailed for each specimen set acquired. The data requested included the date, time, and location of the crash, the time of death of the victim, the time the specimens were taken, the type of accident, single or multiple vehicle, type of collision, road and light conditions, whether or not the dead driver was at fault, and the sex and age of the victim. The flow of materials for the acquisition of specimens is depicted in Figure 1. The 710 specimen sets were collected between December 1971 and September 1973 as shown in Table 1. The sources of specimen sets are shown in Table II. Only 699 specimen sets were returned in a usable condition. Of these, 97% contained the alcohol swabs, 74% contained urine, 98% contained blood, 75% contained bile and 57% contained urine, blood and bile.

---

[1] Midwest Research Institute, Kansas City, Missouri, U.S.A.

TABLE I *Receipt of Specimen Kits by Month*

Month	Specimen Kits Received
June to November 1971	0
December 1971	8
January 1972	12
February 1972	6
March 1972	13
April 1972	23
May 1972	25
June 1972	33
July 1972	32
August 1972	39
September 1972	35
October 1972	46
November 1972	42
December 1972	63
January 1973	55
February 1973	39
March 1973	36
April 1973	53
May 1973	46
June 1973	29
July 1973	29
August 1973	42
September 1 to 4, 1973	4
TOTAL	710

TABLE II *Sources of Specimens*

Seattle, Washington	76
Portland, Oregon	74
Burlington, Vermont	51
Sacramento, California	48
San Diego, California	48
East Meadow, New York	46
Oakland, California	39
Orlando, Florida	36
St. Petersburg, Florida	33
Atlanta, Georgia	32
Cincinnati, Ohio	27
Baltimore, Maryland	22
Minneapolis, Minnesota	17
Everett, Washington	17
Las Vegas, Nevada	15
Tampa, Florida	15
Lincoln, Nebraska	12
Appleton, Wisconsin	11
Akron, Ohio	11
Albuquerque, New Mexico	11
Other Areas	69
TOTAL	710

Analysis of Specimens

Blood (15 ml), urine (20 ml), and bile (10 ml) specimens were hydrolyzed with β–glucuronidase at pH 5.0 and 37°C for over 12 hours to liberate any drugs present from their glucuronides. The hydrolyzed specimens were then filtered and passed through 2g XAD-2 resin in columns at pH 9.2. The drugs were eluted from the columns using 15 ml of a 4:6 mixture of dichloroethane/ethyl acetate. The eluates were evaporated to dryness after acidification with hydrochloric acid to reduce the volatility of basic drugs. The residues were reconstituted in 100 μl methanol and subjected to thin layer chromatography and gas chromatography. The general analysis scheme is depicted in Figure 2.

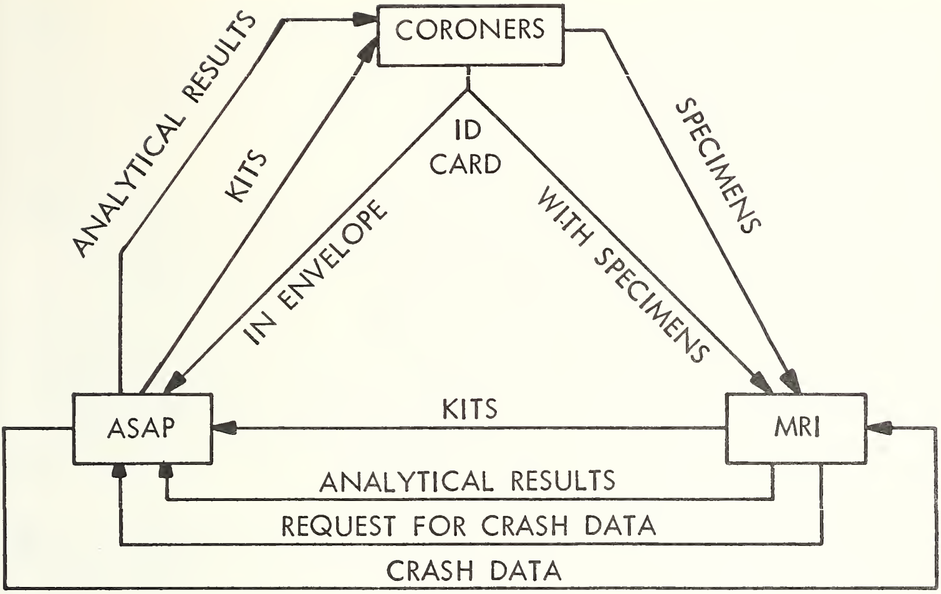


Figure 1 *Diagramatic representation of the flow of information and materials for the acquisition of data on fatally injured drivers.*

The alcohol swabs of the hands and oronasal areas were initially eluted with methanol, and the eluate subjected to thin layer chromatography to detect cannabinoids (marihuana components). This was superceded by a colorimetric test performed on the swab itself using Fast Blue B reagent.

The gas chromatographic technique allowed for the quantification of drugs in urine, blood and bile. Extraction efficiencies of the drugs in question on the XAD-2 columns were estimated using spiked solutions.

The drugs included in the analytical scheme are as shown in Table III. Blood was also analyzed for alcohol using gas chromatography and a head space technique with acetonitrile as an internal standard. Quantification was conducted on all drugs except nicotine, aspirin, salicyclic acid and the cannabinoids. During all analytical procedures, control samples were run simultaneously with the driver specimens to ensure quality control of the analyses.

RESULTS

The frequency with which drugs were found in the body fluids, alcohol washings (swabs) and drivers was noted with the following criteria applying:

Drugs in urine and bile were assigned as being positive only if a level of 1 μg/ml or greater was found.

Drugs including alcohol, in blood were assigned as positive at any level.

Aspirin, nicotine and salicyclic acid were taken to be qualitative only and were assigned positive if found at any level.

Marihuana results were treated in two separate batches, those tested by thin layer chromatography (TLC) and those tested on-the-swab.

The drugs are classified into groups, *i.e.* sedatives/hypnotics, stimulants, antihistamines/decongestants, tranquilizers, narcotic analgesics, and miscellaneous

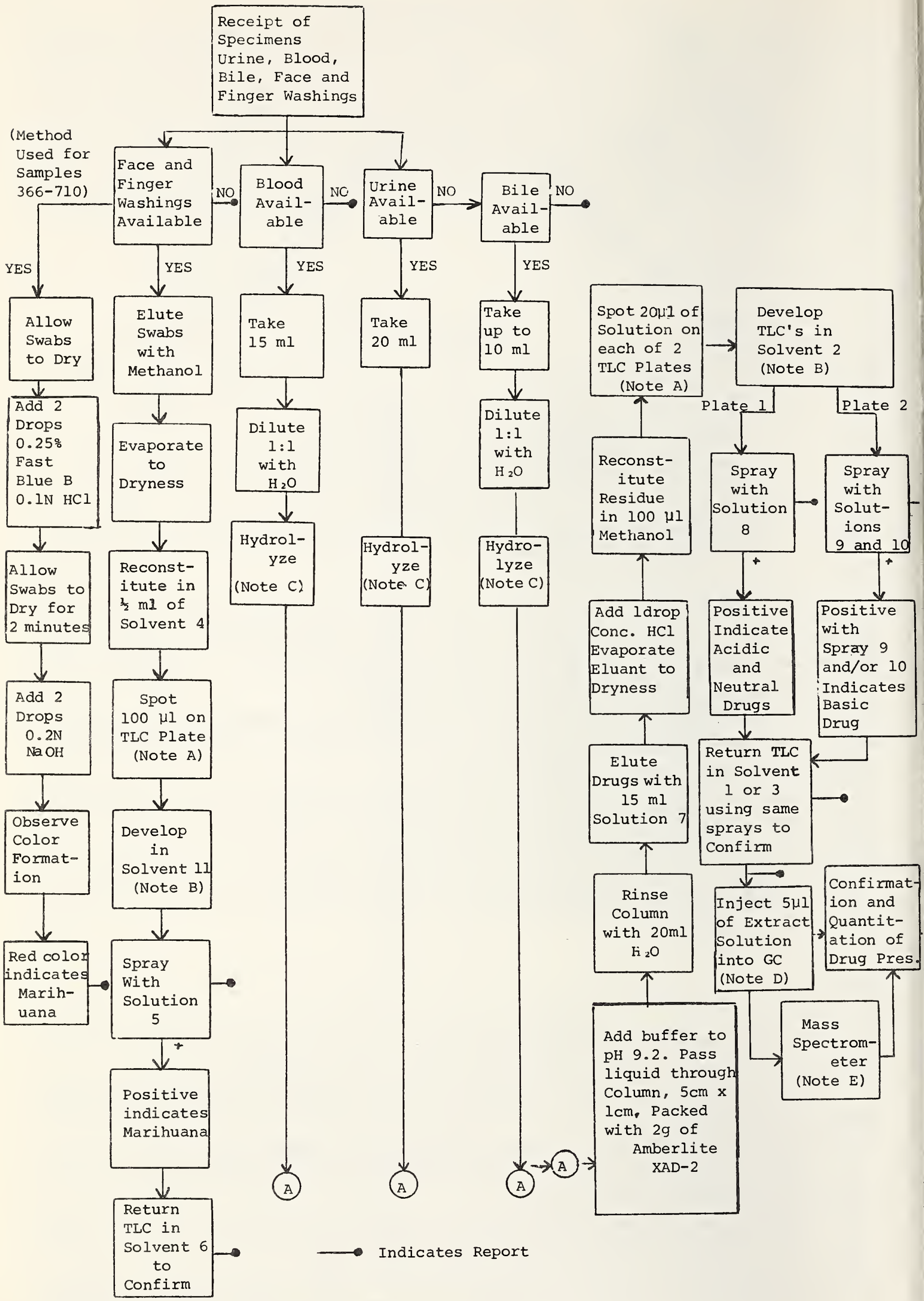

Receipt of Specimens Urine, Blood, Bile, Face and Finger Washings
(Method Used for Samples 366-710)
Face and Finger Washings Available
NO
Blood Available
NO
Urine Available
NO
Bile Available
NO
YES
YES
YES
YES
YES
Allow Swabs to Dry
Add 2 Drops 0.25% Fast Blue B 0.1N HCl
Allow Swabs to Dry for 2 minutes
Add 2 Drops 0.2N NaOH
Observe Color Formation
Red color indicates Marihuana
Elute Swabs with Methanol
Evaporate to Dryness
Reconstitute in ½ ml of Solvent 4
Spot 100 µl on TLC Plate (Note A)
Develop in Solvent 11 (Note B)
Spray With Solution 5
+
Positive indicates Marihuana
Return TLC in Solvent 6 to Confirm
Take 15 ml
Dilute 1:1 with H_2O
Hydrolyze (Note C)
A
Take 20 ml
Hydrolyze (Note C)
A
Take up to 10 ml
Dilute 1:1 with H_2O
Hydrolyze (Note C)
A
A
Add buffer to pH 9.2. Pass liquid through Column, 5cm x 1cm, Packed with 2g of Amberlite XAD-2
Rinse Column with 20ml H_2O
Elute Drugs with 15 ml Solution 7
Add 1drop Conc. HCl Evaporate Eluant to Dryness
Reconstitute Residue in 100 µl Methanol
Spot 20µl of Solution on each of 2 TLC Plates (Note A)
Develop TLC's in Solvent 2 (Note B)
Plate 1
Plate 2
Spray with Solution 8
+
Positive Indicate Acidic and Neutral Drugs
Spray with Solutions 9 and 10
+
Positive with Spray 9 and/or 10 Indicates Basic Drug
Return TLC in Solvent 1 or 3 using same sprays to Confirm
Inject 5µl of Extract Solution into GC (Note D)
Mass Spectrometer (Note E)
Confirmation and Quantitation of Drug Pres.
Indicates Report

Figure 2 *Analysis of body specimens for drugs.*

Note A: *Use 20 x 20 cm silica gel G, 250 μ on glass. Spot extracts, along with standards, 1.0 cm from lower edge of plate. Warm the plate slightly when spotting.*

Note B: *Develop in glass tank with lid. Use solvent to about 0.5 cm depth. Develop the plate 10 cm above spotting line. Remove and dry at room temperature.*

Note C: *Hydrolyze by adding 3900 Fishman Units of β-Glucuronidase, take to pH 5.2, incubate at 37°C for 18 hr, centrifuge and filter.*

Note D: *A Bendix 2500 Gas Chromatograph has been employed. Glass columns 5 ft x 4 mm (ID) with 3% OV-1 on 100/120 mesh Gas Chrom Q. Five microliters of extract solution were injected. Carrier gas is* N_2*, at a flow of 50 ml/min. Detector temperature 250°C, injection port temperature 240°C. Column temperature between 160 and 265°C depending on drugs being analyzed.*

Note E: *The mass spectrometer employed in this analytical scheme is a Varian MAT CH-4. This is connected to the gas chromatograph via a Watson-Biemann helium separator. A Varian 8K core laboratory computer and teletype are employed with the GC/MS setup.*

Solvent 1: *For acidic and neutral drugs-acetone/chloroform, 1:9.*

Solvent 2: *Ethyl acetate/methanol/ammonia, 85:10:5.*

Solvent 3: *For basic drugs-ethyl acetate/methanol/ammonia/benzene, 75:10:2:13.*

Solvent 4: *Benzene/petroleum ether, 1:1.*

Solution 5: *Fast Blue B solution – 250 mg in 100 ml of 0.1 N hydrochloric acid. Follow with a spray of 0.5 N sodium hydroxide.*

Solvent 6: *Benzene/chloroform, 3:7.*

Solution 7: *1,2-Dichloroethane/ethyl acetate, 4:6.*

Solution 8: *Mercuric sulfate solution-suspend 5 g of mercuric oxide in 100 ml water, add 20 ml concentrated sulfuric acid. Cool and dilute to 250 ml with water. Follow with diphenyl carbazone (DPC) solution-dissolve 5 mg DPC in 50 ml chloroform. Follow this with a 0.1 N solution of* $KMnO_4$ *(potassium permanganate).*

Solution 9: *Ninhydrin-commercially available in aerosol bombs from Brinkmann.*

Solution 10: *Iodoplatinate solution-dissolve 1 g platinum tetrachloride in 100 ml water, mix with 300 ml water containing 10 g potassium iodide. Dilute to 400 ml with water.*

Solvent 11: *Benzene.*

TABLE III *Drugs Included in the Analytical Screen*

Sedatives and Hypnotics
Phenobarbital (Luminal)
Pentobarbital (Nembutal)
Amobarbital (Amytal)
Secobarbital (Seconal)
Butabarbital (Butisol)
Butobarbital (Butethal)
Diphenylhydantoin (Dilantin)
Glutethimide (Doriden)
Methaqualone (Quaalude)

Tranquilizers
Meprobamate (Miltown)
Chlordiazepoxide (Librium)
Diazepam (Valium)
Chlorpromazine (Thorazine)
Promazine (Sparine)
Thioridazine (Mellaril)
Trifluoperazine (Stelazine)

Analgesics
Acetylsalicylic acid (Aspirin)
Salicylic acid
Propoxyphene (Darvon)

Stimulants and Antidepressants
Methylphenidate (Ritalin)
Imipramine (Tofranil)
Amitriptyline (Elavil)
Amphetamine (Dexedrine)
Methamphetamine (Desoxyn)

Antihistamines and Decongestants
Chlorpheniramine
Diphenhydramine
Tripelennamine
Methapyrilene
Phenylpropanolamine

Narcotics
Nalorphine (Nalline)
Morphine
Codeine
Meperidine (Demerol)
Cocaine
Methadone (Dolophine)
Hydromorphone (Dilaudid)

Miscellaneous
Dimethyltryptamine (DMT)
Diethyltryptamine (DET)
Lobeline
Mescaline
Methylene dioxyamphetamine (MDA)
Quinine
2,5-dimethoxy-4-methylamphetamine (STP)
Nicotine
Tetrahydrocannabinol (THC)
Cannabinol (CBN)

(Table IV). Frequencies are quoted for each individual drug, each drug group and all drugs (other than alcohol, marihuana, nicotine, aspirin and salicyclic acid). The number of cases of the appearance of a drug in a fluid is given in the Table. This is followed by the percentage of fluid samples in which the drug was found.

Table V indicates the number of times nicotine, aspirin, and salicyclic acid were found in urine, blood, and bile samples. Again, the frequencies are followed by the percentages of fluid samples in which the drug was found.

Table VI shows the blood alcohol concentrations that were found in the 684 blood samples collected. The alcohol level is stratified in quanta of 0.05%. Figures are quoted for drivers who had been drinking alcohol as well as drivers who were drunk, *i.e.* blood alcohol level $\geqslant$0.10%.

Table VII indicates the frequency with which marihuana was found as determined by the swab tests. Results were calculated separately for the TLC test and the on-the-swab test. The differences between swabs tested and swabs available are due to the fact that some swabs were too dirty for testing.

TABLE IV *Frequency with which Quantitated Drugs were Found in Body Fluids.*

	Urine (517 Specimens)		Blood (682 Specimens)		Bile (526 Specimens)	
Drug	Number	Percentage	Number	Percentage	Number	Percentage
Amobarbital	3	0.58	3	0.44	4	0.76
Butabarbital	2	0.39	1	0.15	6	1.14
Butobarbital	1	0.19			2	0.38
DPH					1	0.19
Glutethimide	1	0.19	3	0.44		
Pentobarbital	4	0.77	1	0.15	1	0.19
Phenobarbital	13	2.51	12	1.76	8	1.52
Secobarbital	3	0.58			2	0.38
Sedatives and Hypnotics	27	5.22	20	2.93	24	4.56
Amphetamine	2	0.39	2	0.29		
Imipramine			2	0.29	1	0.19
Methamphetamine			3	0.44	2	0.38
Methylphenidate	1	0.19	1	0.15		
Cocaine			1	0.15		
Stimulants	3	0.58	9	1.32	3	0.57
Methapyrilene			1	0.15		
Phenylpropanolamine	7	1.35			6	1.14
Antihistamines and Decongestants	7	1.35	1	0.15	6	1.14
Meprobamate	2	0.39	1	0.15	7	1.33
Chlordiazepoxide	2	0.39				
Chlorpormazine	1	0.19	1	0.15	2	0.38
Trifluoperazine	2	0.39			2	0.38
Tranquilizers	7	1.35	2	0.29	11	2.09
Morphine	1	0.19			1	0.19
Hydromorphone					2	0.38
Meperidine	1	0.19				
Methadone	1	0.19				
Narcotic analgesics	3	0.58			3	0.57
Quinine	1	0.19				
Lobeline	1	0.19	2	0.29		
Dimethyltryptamine			1	0.15		
Any drug	49	9.48	35	5.13	47	8.94

TABLE V *Frequency with which Nicotine, Aspirin and Salicylic Acid were Found in Body Fluids*

	Urine (517 specimens)		Blood (682 specimens)		Bile (526 specimens)	
Drug	Number	Percentage	Number	Percentage	Number	Percentage
Nicotine	284	54.9	57	8.4	91	17.3
Aspirin	114	22.1	87	12.8	104	19.8
Salicylic acid	29	5.6	7	1.0	20	3.8

TABLE VI *Blood Alcohol Concentrations. N = 684*

BAC g/100 ml (%)	Number of Drivers	Percentage of Total	Cumulative Percentage
0.000	287	42.0	42.0
0.010-0.049	39	5.7	47.7
0.050-0.099	37	5.4	53.1
0.100-0.149	67	9.8	62.9
0.150-0.199	77	11.3	74.2
0.200-0.249	62	9.1	83.3
0.250-0.299	52	7.6	90.9
0.300-0.349	28	4.1	95.0
0.350-0.399	19	2.8	97.8
⩾ 0.400	16	2.2	100.0
> 0.000	397	58.0 ± 3.8	
⩾ 0.100	321	46.9 ± 3.8	

TABLE VII *Frequency with which Marihuana was Found in Drivers*

	Number of Swabs Tested	Number of Positives	Per Cent Positives	Total[a] Per Cent
TLC (357 drivers)	357 sets	6 sets	1.68	N.A.
On-the-swab (323 drivers)				
Right hand	303	80	26.4	33.8
Left hand	305	77	25.2	32.3
Mouth	201	44	21.9	28.1
Complete set	323 sets	124 sets[b]	38.4	49.2
Complete set of three swabs clean enough for testing	195 sets	23 sets[c]	11.8	15.1
		67 sets[b]	34.4	44.1

[a] Adjusted incidence takes into account that the on-the-swab test yielded 78% positives on tests with smokers in laboratory controlled experiments (U.S. Army LWL Report LWL-CR-08C72).

[b] Incidences in which at least one swab was positive per set.

[c] Incidences in which all three swabs were positive.

Table VIII gives the frequencies for quantitated drugs (except alcohol). All the 695 drivers from whom at least one body fluid was collected are included in this Table (four collection kits were received containing only swabs). Frequencies are for the drugs with and without alcohol.

The number of times various quantitated drugs (except alcohol) were found in the 395 drivers from whom all three physiological fluids (urine, bile, and blood) were available are given in Table IX. Again, frequencies are quoted for drug groups, any drugs, and for drugs with and without alcohol.

TABLE VIII *Frequency with which Quantitated Drugs were Found – in Drivers – with and without Alcohol*

Type of Drug	Total		Not Combined with Alcohol		Combined with Alcohol		Combined with Alcohol (BAC ⩾0.100 g/100 ml (%))	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Sedatives and hypnotics	50	7.19	23	3.31	27	3.88	22	3.17
Stimulants	14	2.01	7	1.01	7	1.01	5	0.72
Antihistamines and decongestants	14	2.01	6	0.86	8	1.15	2	0.29
Tranquilizers	18	2.59	5	0.72	13	1.87	7	1.01
Narcotic analgesics	5	0.72	1	0.14	4	0.58	4	0.58
Miscellaneous	5	0.72	2	0.29	3	0.43	2	0.29
Any Drugs	91	13.09	38	5.42	53	7.63	40	5.76

TABLE IX *Frequency with which Quantitated Drugs were Found in Drivers for whom all Body Fluids were available*

Type of Drug	Total		Not Combined with Alcohol		Combined with Alcohol		Combined with Alcohol (BAC ⩾0.100 g/100 ml (%))	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Sedatives and hypnotics	35	8.86	14	3.54	21	5.32	16	4.05
Stimulants	8	2.03	3	0.76	5	1.27	4	1.01
Antihistamines and decongestants	9	2.28	3	0.76	6	1.52	4	1.01
Tranquilizers	11	2.78	2	0.51	9	2.28	5	1.27
Narcotic analgesics	3	0.76	1	0.25	2	0.51	2	0.51
Miscellaneous	1	0.25	0	0.00	1	0.25	0	0.00
Any Drugs	60	15.19	19	4.81	41	10.38	30	7.59

Table X indicates the number of times nicotine, aspirin, and salicyclic acid were found. All 695 drivers from whom at least one body fluid was collected are included in this Table.

TABLE X *Frequency with which Nicotine, Aspirin and Salicylic Acid were Found in Drivers*

Type of Drug	Number	Per Cent
Nicotine	325	46.8
Aspirin	198	28.5
Salicylic acid	40	6.6

Sixty of the specimen sets were received from areas which lent bias to their specimens by submitting those which were suspected to be from drug users. Table XI shows what percentages are obtained when these 60 specimens are removed from the analysis.

TABLE XI *Total Specimens With and Without Bias*[a]

Specimen Kits Received	Total Specimens %	Total Specimens Minus the 60 Biased Specimens %
Blood alcohol	58.0	58.24
Blood alcohol ⩾ 0.100 g/100 ml	46.9	46.24
Marihuana (on-the-swab, all 3+)	11.8	11.96
Nicotine (in urine)	54.9	56.44
Aspirin (in urine)	22.1	23.18
Quantitated drugs (drivers)	13.1	12.60

[a] A Chi-square test reveals no significance to any of these changes.

Finally, a comparison of alcohol and sedative use by drivers, as shown in Table XII, reveals no significant influence on sedative use by alcohol or vice versa. The percentage of drivers consuming sedatives with or without alcohol was 7.19; 6.80% of drivers consuming alcohol were taking sedatives; and 7.72% of drivers not consuming alcohol were taking sedatives.

TABLE XII *Number of Drivers who Used Alcohol and/or Sedatives*

	Drivers Using Sedatives	Drivers Not Using Sedatives	Total
Drivers consuming alcohol	27	370	397
Drivers not consuming alcohol	23	275	298
TOTAL	50	645	695

DISCUSSION

All drugs[2] detected by quantitative analysis (urine, blood, bile) are shown in Table IV. It is apparent that a given drug may be much more detectable in one test than another. A consequence of this is that drug usage would be underestimated if any one of the tests was omitted. This is evident from a comparison of Tables VIII and IX whose frequencies from the total sets of fluids are compared with frequencies from only complete sets. Of course, for a specific drug it may be true that one or two tests would have been sufficient.

Approximately one in 11 urine or bile tests was positive, whereas about one of 20 blood tests was positive. This may be due to the fact that urine and bile are drug concentration centers whereas blood is not.

A positive response to one or more of the quantitated drugs, excluding alcohol, was found in 91 out of 695 drivers (13%). This figure would have been somewhat higher, presumably, if all samples were subjected to all three tests. (Although almost every sample furnished a blood test, this was not true with respect to urine and bile.)

---

[2] Excluding alcohol, marihuana, nicotine, aspirin and salicyclic acid.

Thus, the 13% was an 'underestimate' of the persons using these drugs. If only those sets in which urine, blood and bile were all available were analyzed, a figure of 15% would be obtained (60/395). Sedatives and hypnotics accounted for over half the drug occurrence.

It is apparent from Table V that blood and bile tests greatly underestimate nicotine occurrence. The urine test also detected more aspirin and salicyclic acid, but the discrepancy was much less marked.

Tables VI and VII summarize the results of the BAC test and the marihuana tests. Almost 3 of 5 (58%) drivers had been drinking, and nearly half (47%) were "drunk" (BAC ⩾0.10%).

The original test (TLC) for marihuana detected only six users (1.7%), and was obviously not compatible with the second test (on-the-swab technique) (Table VII). The right-hand/left hand/mouth results were homogeneous and detected 28-34% marihuana usage. Forty-nine per cent of the drivers showed a positive on at least one swab. The percentage of three positive marihuana results (based on the number of samples that permitted all three swab tests) was only 15%. These figures take into account that 78% of marihuana smokers were detected in laboratory tests using the swab technique combined with an on-the-swab color test. It is apparent that the reliability of swab test method for marihuana smoker detection needs evaluation. Of significance in this respect is the fact that lip, forehead, and stomach swabs of six tobacco smokers and six perspiring athletes at the Midwest Research Institute yielded no positives when tested by the on-the-swab technique. Thus, the basic concept of the swab test seems to have merit.

The 50 positive sedative results were examined in an attempt to differentiate between alcohol presence in sedative and non-sedative users. However, in both the had-been-drinking, and drunk categories there was no difference, *i.e.* the sedative user was neither more nor less likely to use alcohol than the non-sedative user.

Stratification

To some extent, it was possible to examine the influence (if any) of age[3], sex, season[4], region[5], time of crash[6], at fault or not, and single vehicle – multiple vehicle on the drug responses.

The responses stratified were: had been drinking, drunk, marihuana[7], salicyclic acid, aspirin, nicotine, stimulants, tranquilizers, antihistamines and decongestants, sedatives and hypnotics, and 'any drug'[8]. However, the three groups, stimulants, tranquilizers, and antihistamines and decongestants did not produce sufficient sample size to yield formal statistical differences.

A summary of influences is:

1. The only drug significantly over-involved in the at-fault category was alcohol.
2. Alcohol was also the only drug over-involved in single-vehicle crashes.

---

[3] Age categories were: ⩽19, 20-24, 25-29, 30-39, 40-49, 50-59, and ⩾60.

[4] "Seasons" are: J-F-M (quarter 1), A-M-J (quarter 2), J-A-S (quarter 3), and O-N-D (quarter 4).

[5] "Regions" are: "Northwest" – Oregon, Washington; "West" – California, New Mexico, Nevada; "East" – Maine, New York, Vermont; "South" – Arkansas, Florida, Georgia, Kentucky, Maryland, Virginia; "Midwest" – Michigan, Minnesota, Nebraska, Ohio, Oklahoma, and Wisconsin.

[6] Time Categories were: 0000-0059, 0600-1119, 1200-1799, and 1800-2399.

[7] Using only the results after the method was changed to the on-the-swab method.

[8] Any drug detected by a quantitative analysis (except alcohol).

3. Alcohol was the only drug upon which time-of-day was a significant influence (with, of course, increasing usage as time increases).
4. Region was not a significant stratification for any response.
5. Age was a significant factor only with respect to alcohol. (Unfortunately, age was often not known and many of the comparisons were based on small sample sizes.)
6. Sex was a factor with respect to alcohol and nicotine usage, but not otherwise. In both cases males were over-involved.
7. The factor season (quarter) was associated with all responses except alcohol and nicotine. Thus, marihuana was found to be a spring-summer 'activity', and aspirin a winter 'activity'.

It is clear that alcohol was by far the most dangerous drug examined in this study. Alcohol was used by many more people than any other drug (except nicotine) and thus, its usage was much easier to analyze statistically. Unfortunately, it was not possible to find enough users of drugs such as amobarbital to draw a statistically significant sample. With the exception of the combination alcohol-sedatives, no synergistic possibilities were examined.

Finally, the drug groups tranquilizers, antihistamines, and stimulants did not furnish a large enough sample to be stratified meaningfully. The study suggests, however, that males were over-represented amongst users of tranquilizers and antihistamines, and that young people were over-represented amongst those who used stimulants.

The Relationship Between Self-Reported Drunken Driving, Alcohol Consumption, and Personality Variables Among Norwegian Students

Olav Irgens-Jensen[1]

Norwegian traffic-alcohol legislation, which has remained virtually unchanged since 1936, may be said to be very stringent compared with legal approaches to drunken driving in other countries. Almost without exception, unconditional penalties – the least of which is 21 days' imprisonment and one year's suspension from driving – are imposed on persons convicted of driving with a blood alcohol concentration (BAC) exceeding the statutory limit of 50 mg/100 ml. As the penalties imposed in Norway for other offences are exceptionally light, drunken drivers represent a comparatively large proportion of the prison population. More than one-third of the people committed to prison in 1971 were persons convicted of drunken driving. Despite their strictness, however, the laws against drunken driving and their uncompromising enforcement seem on the whole to be supported by public opinion (5). Also, it has been shown that, compared to other countries, the incidence of drunken driving in both accident and non-accident traffic in Norway is very low (1, 2).

Nevertheless, a substantial proportion of the adult population of Norway admit to having driven with an alcohol concentration above the statutory limit (7). In the present study, for example, 24% of a representative sample of students admitted having done so (Table I).

Studies undertaken in Scandinavia reveal that a comparatively large proportion of persons charged with driving under the influence of alcohol, regardless of whether or not they were involved in accidents, had been convicted of other offences, were from the lower socio-economic groups, and exhibited symptoms of having an alcohol problem (3, 6). This being the case it might be asked, what about those who admit to having driven with an alcohol concentration above the statutory limit but have not run foul of the law? Do many of them also have alcohol problems? Do they exhibit specific personality traits? And do they, furthermore, tend to have committed other criminal offences more often than those who have not been guilty of drunken driving? These are some of the questions our study was designed to answer.

METHOD

The study was based on a questionnaire dealing with drunken driving and personality variables which was circulated among a representative sample of students at the

---

[1] National Institute for Alcohol Research, Oslo, Norway.

University of Oslo in 1969. This questionnaire, which was answered anonymously, was completed by 78% of the sample – a relatively high response percentage. Subsequent checks showed that the students who had completed the questionnaire did not differ appreciably from the general run of students in regard to such factors as age, sex, subjects studied, and time spent at the University.

However, in a survey of this kind the question of representativeness is not of decisive importance as interest centres mainly on the correlations, if any, between different variables within the sample itself. This sample comprised 1,066 persons.

RESULTS

Drunken Driving and Drinking Habits

A total of 24% of the sample – 251 students altogether – admitted to having driven at least once with an alcohol concentration in excess of the statutory limit of 50 mg/100 ml and of these 251, only two admitted to having been arrested for drunken driving. There was a big difference between the percentages for men and women: of the 738 men, 28% admitted to having driven under the influence of alcohol, whereas 13% of the 328 women admitted to having done so.

Two circumstances obviously contribute to the difference in the figures for men and women. In the first place, men still drive more than women. For example, in 1972 about 60% of the male population of Norway over the age of 18 held driving licences, against 30% of the females. In the second place, men have always tended to drink more alcohol than women, and even among students this rule still seems to apply.

TABLE I *Yearly Alcohol Consumption, Men and Women*

Yearly consumption of pure alcohol	Percentage	
Centilitres	Men	Women
0	3	4
1 - 99	21	35
100 - 299	26	35
300 - 699	29	19
700 +	21	7
TOTAL	100	100
Base of percentage	712	320

Table I illustrates the total annual consumption of pure alcohol by the men and women in the sample, estimated on the basis of information on drinking frequency and the average quantities of beer, wine, and spirits drunk in various circumstances. Very few of the students – 3% of the men and 4% of the women – claimed not to have drunk any kind of alcoholic beverage during the preceding 12 months. On the other hand, no less than 21% of the men and 7% of the women said they had drunk as much as 7 litres or more of pure alcohol during the last year. On the average the men proved to have drunk almost twice as much pure alcohol a year as the women.[2]

TABLE II *Self-Reported Drunken Driving and Yearly Alcohol Consumption*

Yearly consumption of pure alcohol	Drunken drivers %		Base of Percentage	
Centilitres	Men	Women	Men	Women
0	0	0	20	13
1 - 99	5	4	150	112
100 - 299	22	10	189	110
300 - 699	39	24	205	62
700 +	49	48	148	23
TOTAL	28	13	712	320

The relationship between the total self-reported consumption of alcohol in a year and drunken driving is shown in Table II. Among the few in the sample who had not drunk any kind of alcoholic beverage at all during the preceding year, not one had ever driven with an alcohol concentration above the statutory limit; of those who had drunk less than one litre of pure alcohol, 5% of the men and 4% of the women had done so; among those who had drunk between one and three litres, 22% of the men and 10% of the women had done so, and among those who had drunk seven litres or more, almost one-half of the men and women had driven with an alcohol concentration above the legal limit. The expected relationship between alcohol consumption and self-reported drunken driving is thus clearly shown.

It is interesting to note that among the few women who had drunk as much as seven litres or more, the percentage who admitted to drunken driving was as high as among the men. It seems probable that among women, drinking heavily tends to reflect a deviation from the norm more than it does in the case of men. It is therefore more likely to be symptomatic of personality problems in women than in men. As will be seen, such problems may predispose a person to drunken driving.

The different manifestations of a person's drinking habits which combine to form the measure of that person's total alcohol consumption, display definite correlations with drunken driving, as shown in Table III. For both men and women, however, there is a greater correlation between drunken driving and *drinking frequency* than between drunken driving and the *quantities* of alcoholic beverages usually drunk at a time. In the case of men the correlation is greatest in regard to the frequency of beer drinking, in that of women in regard to the frequency of wine drinking. This simply reflects the preference of the male student for beer and of the female student for wine. If we are to attempt to estimate the chances of that person driving a car under the

---

[2] On the average, estimates of alcohol consumption based on survey studies do not cover more than 50% of the "true" value of consumption shown in alcohol sales statistics (6). In our study, however, we are not concerned with the actual quantity of alcohol consumed, but in *comparing* groups with different levels of consumption. We assume, however, that the groups that reported drinking most did in fact have the highest consumption.

TABLE III *Correlation Between Self-Reported Drunken Driving and Drinking Habits*

Drinking Habits	Self-reported drunken driving			
	men		women	
	gamma coef.	N	gamma coef.	N
Frequency of beer drinking per year	0.60*	732	0.59*	327
Frequency of wine drinking per year	0.50*	719	0.66*	321
Frequency of spirits drinking per year	0.48*	721	0.60*	325
Average quantity of beer drunk on each occasion	0.38*	732	0.41*	327
Average quantity of wine drunk on each occasion	0.35*	718	0.46*	326
Average quantity of spirits drunk on each occasion	0.40*	720	0.51*	324
Total alcohol consumption per year	0.56*	712	0.68*	320
Drinking problems index	0.42*	720	0.39***	322
Aggressive behaviour index (when intoxicated)	0.49*	738	0.42*	328

* $p \leq 0.001$
*** $p < 0.05$

influence of alcohol, it would appear to be more important to establish *how often* a person drinks than *how much* he or she usually drinks on each occasion. Naturally, people who drink frequently, also tend more often to find themselves in situations entailing the need to drive a car, even if the percentage of alcohol in their blood exceeds the statutory limit. On the other hand, drinking a relatively large quantity in a situation in which drinking is the accepted thing to do, will often disuade a person from driving, at least in a country such as Norway, where the penalties for drunken driving are so severe.

The questionnaire also contained questions designed to determine whether a person's use of alcohol could be indicative of underlying drinking problems. Respondents were asked whether they drank to the point of intoxication when they were alone, whether they resorted to "a hair of the dog that bit them" the morning after, whether their drinking had adversely affected their studies, and whether they had sought advice on or help with their drinking problems. Table III shows that an index based on these questions also revealed a significant correlation with drunken driving: for men this correlation was 0.42, for women 0.39. The answers to questions on aggressive behaviour when intoxicated (for example, how often drinking had led to the respondent's wilfully breaking and damaging things, acting more rashly or obstreperously than usual) also revealed a correlation with drunken driving (Table III).

In summary, self-reported drunken driving, which had very rarely led to an accident or come to the attention of the police, showed not only a definite correlation with the general consumption of alcohol, but also with signs of potential drinking problems and tendencies towards aggressive conduct when intoxicated.

Drunken Driving and Personality Variables

A number of studies have shown that problem drinkers, especially male problem drinkers, have a tendency to drive more recklessly, and to be involved more frequently in highway accidents than other people. This may, of course, be because such drinkers are more inclined to drive when under the influence of alcohol, but the connection has also been taken to indicate that they have personality traits that predispose them not only to problem drinking, but also to reckless driving – both traits typifying the daring and aggressive male role (4, 9).

In our study we constructed different measures of personality traits. One such measure was designed to determine neurotic tendencies and was based on questions relating to difficulty in concentrating, over-anxiousness, social insecurity, psychosomatic symptoms, etc. Another measure, popularly referred to as the "psychopathic" index, was based on questions similar to those in the Psychopathic Deviant Scale from the Minnesota Multiphasic Inventory. Finally, we included special questions on suicidal impulses and sexual problems.

TABLE IV *Correlation Between Self-reported Drunken Driving and Personality Variables*

Personality Variables	Drunken Driving			
	men		women	
	gamma coef.	N	gamma coef.	N
Neuroticism index	0.09	738	0.09	320
"Psychopathic" index	0.37*	738	0.37***	320
Suicidal impulses	–0.14	738	0.39***	320
Sexual problems	–0.02	738	0.41**	320

* $p \lesssim 0.001$
** $p \lesssim 0.01$
*** $p < 0.05$

Table IV shows that there is *no* correlation between drunken driving and a person's neuroticism index. As neurotic traits have often been found to correlate with various symptoms of problem drinking, this may come as a surprise. A possible explanation is that a person suffering from neurotic anxiety may feel an overriding need to retain self-control and only dares to take chances to a limited extent. The so-called "psychopathic" index, on the other hand, revealed a definite relationship with drunken driving – and the question in this index that showed the highest correlation with drunken driving was precisely: "Do you like taking chances?". An overall evaluation of the questions that make up the "psychopathic" index suggests that both the men and the women in our sample, who had driven under the influence of alcohol, were more subject than the others to aggressiveness and inability to control their impulses, and found planning ahead difficult.

In regard to suicidal impulses and sexual problems, Table IV shows that for men there is no correlation with drunken driving but there is clearly such a correlation for women. The lack of correlation for men seems to accord with the theory that male problem drinkers tend to aspire to tough, independent masculinity. Because there is a correlation for women it seems likely that the personality traits that predispose women to drunken driving are not the same as those that so predispose men. Some of the personality variables we have discussed show a certain correlation with the overall consumption of alcohol; this is particularly true of the "psychopathic" index.

TABLE V *Yearly Alcohol Consumption and "Psychopathic" Index for Self-Reported Drunken Drivers*

Yearly Consumption of Pure Alcohol	Drunken Drivers							
	Men				Women			
	"Psychopathic" index				"Psychopathic" index			
	Low		High		Low		High	
Centilitres	%	Base of %	%	Base of %	%	Base of %	%	Base of %
0	0	11	0	9	0	10	0	3
1 - 99	1	98	14	52	3	60	4	52
100 - 299	18	114	29	75	8	52	12	58
300 - 699	34	104	45	101	10	20	31	42
700 +	44	66	54	82	63	8	40	15
TOTAL	22	393	37	319	9	150	17	170

Table V shows, however, that in regard to drunken driving the percentages differ between a low and a high "psychopathic" index for the various levels of alcohol consumption in the case of both men and women. In other words, we have found a connection between personality traits and self-reported drunken driving which cannot be explained by differences in alcohol consumption alone.

Drunken Driving and Criminality

It was mentioned above that many of the drunken drivers apprehended by the police had criminal records resulting from other types of offence. Table VI shows that even self-reported drunken driving – in the case of men and women alike – correlates with a criminality index based on self-reported criminal offences such as vandalism, robbery, all kinds of theft, smuggling, illegal hunting and fishing.

TABLE VI *Self-Reported Drunken Driving and Other Self-Reported Criminal Offences*

Criminality Index	Drunken Drivers			
	Men		Women	
	%	Base of %	%	Base of %
0	9	140	7	168
1	25	191	14	100
2	25	173	19	43
3	45	222	57	14
TOTAL	28	726	13	325

Some of the students in our sample had actually been prosecuted, and a number convicted, for some of these self-reported offences. Of these, one half admitted to drunken driving. Altogether, our data show that a definite connection exists between driving with an alcohol concentration above the statutory limit and a tendency to commit other offences.

Drunken Driving, Smoking, and the Use of Other Drugs

It is not only use of alcohol that correlates with self-reported drunken driving; use of other drugs does so too. As can be seen from Table VII, there is a clear correlation between smoking and drunken driving for both men and women. There is also a certain correlation between ever having used cannabis and drunken driving, but this correlation is not significant, as only a rather small percentage (about 5%) of the students said that they had ever used cannabis. The correlation between drunken driving and use of drugs other than alcohol partly reflects, however, the commonly found tendency towards multiple drug use.

TABLE VII *Correlation Between Self-Reported Drunken Driving, Smoking, and Use of Other Drugs*

	Drunken Driving			
	Men		Women	
Use of:	gamma coef.	N	gamma coef.	N
Tobacco	0.38*	733	0.55*	327
Cannabis	0.22	736	0.40	327
Barbiturates	0.11	736	0.42*	328
Tranquillizers	–0.01	734	0.34**	326

* $p \leq 0.001$
** $p < 0.01$

In the case of women there is also a correlation between drunken driving and the taking of barbiturates and tranquillizers. The women in our sample tended to take these legally prescribed drugs far more frequently than did the men. The fact that it is primarily in the case of women that a correlation exists between drunken driving and the use of barbiturates and tranquillizers further indicates that a psychological predisposition towards drunken driving does *not* manifest itself in the same way in women as in men.

Drunken Driving and Social Background

Table VIII shows that certain background variables also correlate with drunken driving. That the measure we employed for social standing and which was based on the father's income and education shows such a correlation is not unexpected, since there is reason to believe that even today there are still more students from the higher social strata with cars than from the lower.

TABLE VIII *Correlation Between Self-reported Drunken Driving and Background Variables*

Background Variables	Drunken Driving			
	Men		Women	
	gamma coef.	N	gamma coef.	N
Father's social standing	0.24**	720	0.49*	308
One or both parents total abstainers	–0.29*	729	–0.37***	326
Degree of parents' religiousness	–0.15	736	–0.49*	326

* $p < 0.01$
** $p < 0.001$
*** $p < 0.05$

Furthermore, there were relatively few drunken drivers among those who came from homes in which the parents were total abstainers and/or deeply religious. Temperance and religion are by tradition closely associated in Norway, as most of the major religious movements in the country are of a highly puritanical nature.

An Overall Evaluation

We have seen that self-reported drunken driving among students shows a correlation not only with certain drinking variables, but also with other variables. However, to a greater or lesser extent many of the latter correlate with the drinking variables and are, in addition, in varying degrees, intercorrelated. A multiple regression analysis (MCA) –

which takes into account the intercorrelations between *all* the variables dealt with – showed that of these variables, the total alcohol consumption correlation and drunken driving, gave the highest correlation. The correlation (eta value) between this variable alone and drunken driving was almost as great as the multiple correlation for all the variables together, being 0.36 for men and 0.39 for women, while the total multiple correlation coefficients were 0.41 and 0.42 for men and women respectively.[3]

On the other hand, the regression analysis further showed that, taken together, the variables not directly connected with drinking revealed a definite multiple correlation with drunken driving, with coefficients of 0.33 for men and 0.32 for women. In other words, it is possible to some extent to determine whether a person is likely to drive with a BAC in excess of the statutory limit even when no information is available on that person's drinking habits or drinking problems.

Of the variables not linked with drinking, the following proved most important in connection with drunken driving. For men they were Criminal Index, Smoking Habits and "Psychopathic" Index; for women they were Smoking Habits, Criminal Index and Use of Barbiturates.

Thus, certain features appear to be common to both men and women as regards the variables that best correlate with drunken driving, but there are also certain differences.

The main conclusion to be drawn from the foregoing seems to be that self-reported drunken driving is connected first and foremost with drinking *habits*, and in particular with the total consumption of pure alcohol. If the validity of the hypothesis commonly held by epidemiological researchers in the field is accepted – that the number of users of alcohol with a relatively high consumption in a population corresponds directly to the total use of alcohol in that population – it is probable that the factors determining the total use of alcohol will also determine the incidence of drunken driving to a certain extent. Accordingly, to reduce the incidence of drunken driving, endeavours would have to be made to reduce the total use of alcohol in the population – assuming, of course, that all other relevant factors, such as the number of cars, driving time, and legislation were equal.

The data show, however, that the incidence of self-reported drunken driving appears to be determined not only by alcohol consumption or drinking habits *per se*, but that predisposing factors connected with personality also play a part. If alcohol consumption in a population is relatively low, paradoxical though it may seem, the alcohol consumed will probably be consumed to a large extent by those who ought not to do so, *i.e.* people who are predisposed to alcohol problems and to drunken driving. It would appear difficult, however, to reduce the number of persons who are psychologically disposed to drunken driving unless, at the same time, attempts are made to change some of the cultural values and ideals that are integral features of many societies.

---

[3] As a multiple regression analysis cannot be undertaken on the basis of gamma coefficients, other correlation coefficients have been used. These, partly because of the dichotomization of many of the variables, are on the whole much lower than the corresponding gamma coefficients.

REFERENCES

1. Andenaes, J. and Hauge, R., Uaktsomt drap. *Nordisk Tidsskrift for Kriminalvidenskab* 54, 1-32, (1966).
2. Bøe, O. *"Screening" av Alkoholbelastningen blant Bilførere i Normal Trafikk.* Rapport fra Transportøkonomisk institutt, Oslo, 1972.
3. Kaltenborn, A. M. *Fyll, bil og Fengsel.* Mimeograph, Oslo, 1967.
4. McClelland, D. C., Davis, W. N., Kalin, R., Wanner, E., *The Drinking Man.* New York, 1972.
5. Norseng, P. Lov og rett. In Alstad, B. J. *Norske Meninger II. Politikk og Samfunn.* Oslo, 63-102, (1969).
6. Pernanen, K. Validity of survey data on alcohol use. In *Research Advances in Alcohol and Drug Problems* 1, 355-374, (1974).
7. Stangeland, P. and Hauge, R. *Nyanser i Grått.* Oslo, 1974.
8. Statens offentliga utredningar. *Trafiknykterhetsbrott.* Stockholm, 1970.
9. Zucker, R. A. Sex-role Identity Patterns and Drinking Behaviour of Adolescents. *Quarterly Journal of Studies on Alcohol.* 29, 868-884, (1968).

Alcohol Abuse in First Offenders Arrested for Driving While Intoxicated

Eric W. Fine[1], Pascal Scoles[1] and Michael J. Mulligan

This study was carried out in the City of Philadelphia, Pennsylvania, U.S.A. from January, 1973 through June, 1974. It involved 2,647 subjects, who were persons who had been arrested in the city for the first time for driving while intoxicated (DWI), and who had no previous major arrest record. This group represented approximately 28% of the total arrests for DWI in the city during that period (8).

The investigation was performed as part of a collaborative effort by the police, the judiciary, the Department of Probation and Parole, the National Council on Alcoholism and mental health professionals, in a city-wide effort to evaluate and manage the problem of the intoxicated driver. The program is coordinated through the City's Managing Director's office, and the Philadelphia Coordinating Office For Drug and Alcohol Abuse Programs. In conjunction with this research, the Delaware Valley branch of the National Council on Alcoholism operates a safe driving clinic, intended as an educational strategem directed towards providing factual information concerning drinking and driving, to clients arrested for DWI and referred from the courts.

The responsibility for evaluation was assumed by the West Philadelphia Community Mental Health Consortium through its Alcoholism Program. A team of 8 interviewers, with at least bachelor degrees in the social sciences and interviewing experience, was employed, and an introductory training course was given which emphasized the acquisition of reliable, objective data, with minimal personal or moralistic attitudes concerning drinking being allowed to influence the evaluation.

Although there is a great deal known about the association between alcohol consumption and impairment of driving behaviour, there remain many areas of uncertainty. One of the major controversial issues is concerned with the incidence and type of alcohol abuse found in populations of drinking drivers (5). Until quite recently, it was customary to blame alcohol-involved traffic accidents on the social or casual drinker. Numerous studies, however, analyzing drinking patterns of accident-involved drivers, reveal that a large proportion of these drivers have serious alcohol problems (1, 2, 7, 9, 12, 13, 14, 15, 18).

Selzer *et al.* (10) investigated 67 persons arrested for driving while intoxicated in Ann Arbor, Michigan, and found that 37 (55%) were alcoholics, 10 (15%) were

---

[1] Eric W. Fine, Director, Alcoholism Treatment Program Pascal Scoles, Director, Alcohol-Highway Safety Program West Philadelphia Community Mental Health Consortium, Philadelphia, Pennsylvania 19101, U.S.A.

borderline cases, and 4 (6%) were pre-alcoholic, leading to a total of 76% with alcohol problems. Selzer and Weiss (13) attempted to determine the incidence of chronic alcoholism in drivers responsible for fatal accidents, and concluded that 72 drivers (40%) were alcoholic, 10% were pre-alcoholic, and 50% were non-alcoholic. These studies are further corroborated by accident records of known alcoholics (13, 16) (defined as those in treatment for alcohol abuse), which reveal that alcoholics are involved in more total accidents, and are more frequently convicted of drunken driving, than the population at large. A significant study by the State of California Transportation Agency revealed that a correlation of 0.92 exists between drunken drivers' alcohol levels at the time of their fatal accidents and their previous number of drunkenness arrests. This indicates that in 80% of the cases, a drunken high-blood-alcohol-level driver who kills someone has had a prior drunken driving arrest (17).

It is highly likely that a significant proportion of persons arrested for driving while intoxicated have serious levels of alcohol impairment, but a clear understanding of this problem has been handicapped by the continued use of such subjective and non-measureable terms as alcoholic and pre-alcoholic.

People labelled "alcoholics" constitute an appreciable proportion of those involved in automobile accidents (2, 5, 9, 10, 15) but the question remains as to what exactly constitutes alcoholism, and why it is so variously defined in the numerous studies. It is obviously of critical importance to know what proportion of individuals, if any, have a compulsive need to drink alcohol, if relevant treatment strategies are to be designed. If, in fact, this compulsivity is a significant factor, then programs depending on legal sanctions or punishment, for example, are unlikely to be successful.

During the early planning stages for the Philadelphia Alcohol-Safe Driving Program, it was decided that the program design should be based primarily on sound, factual information concerning the characteristics of the target population. Without knowing the specific alcohol use and abuse patterns, and the sociodemographic variables of this particular population, it would be unlikely that a program for its management would relate to its possibly unique needs.

Factual information regarding the Philadelphia Alcohol-Safe Driving Program was obtained through a Client Evaluation Form. This form included a Drinking Behavior Interview and a series of questions regarding age, sex, race, marital status, current and past family drinking patterns, drug use patterns, social class, etc.

This report concentrates on some of the findings that are considered important in relation to alcohol impairment. Significance was determined by the Chi Square statistic, at the .05 level.

ALCOHOL IMPAIRMENT – A MEASURE OF CHANGE IN DRINKING HABITS

A set of 15 questions based on the Drinking Behavior Interview procedure developed by Shelton, Hollister and Gocka (14) was used to measure an individual's drinking pattern, and its effect on one's social and economic functioning.

The Drinking Behavior Interview attempts to measure the physical influence of different types of alcoholic beverages (beer, wine, and liquor) by synthesizing into a single number the rate and total consumption of absolute alcohol ingested in the past month. The rationale behind the indicator is that particular threshold values of absolute alcohol intake into the bloodstream result in varying degrees of impairment. From clinical experience, it was decided that it would be appropriate to describe three levels of alcohol impairment designated as Level I, II, and III.

Level I

Individuals who typically consumed alcoholic beverages up to 3 quarts of beer, or less than 6 shots of whiskey or less than 3 water glasses filled with wine at most twice weekly were included here. They usually enjoy drinking with others and rarely drink alone.

Level II

This comprised individuals who typically consumed up to 5 quarts of beer, one-fifth of wine and/or 2 pints of liquor, 3 or 4 times a week. Level II drinkers exhibited one or more of the following behavior characteristics: being 'high' up to 10 times a month; long periods of continued drinking ranging over 6 hours; at times drinking upon awaking; reported 'memory lapses' or 'blackouts'; often complaining of some other 'nervous' disorders; missing meals because of drinking habits; and drinking occasionally during working hours.

Level III

An individual who typically consumed alcoholic beverages daily is considered a Level III drinker. His daily intake of alcohol was *usually* 5 or more quarts of beer, or one fifth or more of wine, or 3 or more pints of whiskey. Level III drinkers had one or more of the following behavior characteristics: they were 'high' more than 10 times a month; they often drank continuously for periods of more than 12 hours at one drinking session; they reported 'memory lapses' or 'blackouts' for many of their drinking episodes; their drinking habits frequently interfered with eating patterns, and they missed a number of meals. These individuals invariably reported beginning their day with a drink and continuing to drink at frequent intervals during the day.

FINDINGS

Levels of Alcohol Impairment

The levels of impairment of 2,647 first offenders arrested for DWI are shown in Table I. It can be seen that a significant proportion (58%) of this population (Levels II and III) reported a constant regular abuse of alcohol. Since all clients were referred from the court system, one could reasonably suspect some under-reporting of their alcohol intake and a minimizing of the reported effect of alcohol on their behavior, due to fear of judicial action.

TABLE I *Levels of Alcohol Impairment*

Type	N	%
Level I	1,111	42%
Level II	1,331	50.3%
Level III	205	7.7%
Total	2,647	100%

Age

Table II shows that drinking behavior differed with age. It is apparent that the highest per cent (68.4%) of Level II and Level III drinkers occurred in the 20-24 age group and the type of drinking typical at these levels decreased with advancing age; conversely, Level I type drinking increased with advancing age. It should be noted that, after age 44, problem drinking falls below that reported for individuals under 20 years of age.

TABLE II *Age and Levels of Alcohol Impairment*

Age	(Social Drinking) Level I		(Problem Drinking) Levels II & III	
	N	%	N	%
Below 20	30	41.7	42	58.3
20-24	95	31.6	206	68.4
25-34	250	38.6	397	61.4
35-44	275	39.9	415	60.1
45-54	283	46.6	324	53.4
55-64	153	53.9	131	46.1
65+	25	54.3	21	45.7
Total	1,111		1,536	

Socio-Economic Status

Utilizing the Hollingshead and Redlich Social Position Scale, it was reported that 88% of the population were in class IV and V (lower social position). The mean annual income was $8,519.00.

Several statistical associations were found relating alcohol impairment to race, sex, and marital status. These are considered to have practical importance for the total management of the problem.

Racial Origin

The DWI sample consisted of 49% Black and 47.8% White as compared with a city-wide distribution of 33.6% Black and 65% White (4). The reported levels of alcohol impairment in Blacks and Whites were significantly different ($\chi^2 = 7.522$; $p < .02$). Blacks as a group exhibited more serious drinking patterns than Whites (Blacks 39% Level I; 61% Levels II and III; Whites 44.3% Level I; 55.7% Levels II and III). The Whites seemed to be more serious drinkers in the early 20s and the Blacks seemed to be more serious drinkers in their middle 30s through middle 50s.

Sex

An overwhelming 93.5% of the first offenders arrested for DWI was male. A comparison of the drinking behaviors of males and females revealed that a significant difference exists between the sexes ($\chi^2 = 15.71$; $p < .001$). Females in this sample reported less problem drinking than males (43.6% Level II and III as compared to 59.1% for male offenders).

Marital Status

Fifty-two per cent of the sample were married, with the remaining 48% being single (21.5%), widowed (3.7%), divorced (8.2%) or separated (14.2%). Married individuals showed significantly less alcohol impairment as a group than any non-married group ($\chi^2 = 8.72; p < .05$).

CONCLUSION

The findings reported here suggest that, compared with the norms established by Cahalan and his colleagues (3) for American drinking practices, this group of first offenders arrested for DWI had a significantly different, and more serious, alcohol use pattern than the population at large. Although females represented only 6.5% of the sample, they had a particularly severe alcohol abuse pattern compared with the general female population. The levels of impairment associated with alcohol consumption were very definitely related to age, with a significantly greater incidence of alcohol problems occurring in the younger age groups. An important implication is that there did not appear to be a progressive, cumulative increase in alcohol impairment over time. Probably periods of remission occur, and with the passage of time serious problem drinking in some individuals may be superseded by lower levels of alcohol intake and relatively problem-free drinking behavior.

It is also important to note that even those persons in the present study who, admitted to a high proportion of pathological drinking behavior, were hardly ever motivated to seek treatment. Less than 2% reported ever having been in any form of treatment program related to drinking, and over 90% felt that their drinking behavior prior to arrest was causing them no problem.

The findings explain to some extent why laws, punishment (including imprisonment), and appeals to reason and intelligence have proved to be relatively ineffective deterrents to operating motor vehicles while under the influence of alcohol. One of the explanations might be the failure of these methods to address themselves to the significant proportion of offenders who have very serious levels of alcohol impairment, and these are persons who have drinking patterns which almost certainly include a compulsive need to drink.

Effective management of this population must involve a multi-modality treatment program, flexible enough to adjust treatment strategies as determined by individual client needs and judicial demands. In view of the apparent lack of insight into the severity of their drinking problems and the almost non-existent motivation to obtain treatment, the indications are that some form of compulsory program will need to be instituted for these offenders. The nature of this particular alcohol-impaired population makes it extremely unlikely that they would respond well to the rather restricted approach adopted by most existing alcoholism treatment programs, or to self-help groups such as Alcoholics Anonymous. On the basis of clinical experience with many of these individuals, it is evident that total abstention from alcohol should be only one of several options available, and an excellent opportunity exists here for approaches directed to more responsible use of alcohol, especially so far as drinking and driving are concerned.

It is imperative that a very close working relationship is established, and maintained, between the criminal justice system and the treatment agency, so as to ensure comprehensiveness and continuity. Law enforcement practice and mental health principles should be meaningfully integrated to meet mutual concerns.

REFERENCES

1. Borkenstein, R. F., Around the World with Alcohol, *Traffic Safety* 71, 8-9 and 39-40 (1971).
2. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B. and Zylman, R., *The Role of the Drinking Driver in Traffic Accidents.* Department of Police Administration, Indiana University, 1964.
3. Cahalan, D., Cigin, I. H. and Crossley, H. M., *American Drinking Practices.* Rutgers Center of Alcohol Studies, Monograph 6, 1969.
4. *Census Tracts of Philadelphia and New Jersey 1970.* U.S. Department of Commerce, 1971.
5. Fine, E. W. and Scoles, P., Alcohol, Alcoholism and Highway Safety, *Public Health Reviews* (Tel Aviv). In Press, 1974.
6. Hollingshead, A. B., *Two Factor Index of Social Position.* New Haven, Yale University Press, 1956.
7. McCarroll, J. K. and Haddon, W., A Controlled Study of Fatal Automobile Accidents in New York City, *Journal of Chronic Diseases* 15, 811-826 (1962).
8. *Philadelphia Police Department Statistical Report 1973.* City of Philadelphia, 1974.
9. Popham, R. D., Alcoholism and Traffic Accidents, *Quarterly Journal of Studies on Alcohol* 17, 225-232, (1956).
10. Selzer, M. L., Payne, C. E., Gifford, J. D. and William, L, K., Alcoholism, Mental Illness and the Drunk Driver, *American Journal of Psychiatry* 120, 326-330 (1963).
11. Selzer, M. L. and Payne, C. E., Automobile Accidents, Suicide and Unconscious Motivation, *American Journal of Psychiatry* 119, 237-240 (1962).
12. Selzer, M. L., Payne, C. E., Westervelt, F. H. and Quinn, J., Automobile Accidents as an Expression of Psychopathology in an Alcoholic Population, *Quarterly Journal of Studies on Alcohol* 28, 505-516 (1967).
13. Selzer, M. L. and Weiss, S., Alcoholism and Fatal Accidents: A Study in Futility, *American Journal of Psychiatry* 122, 762-767 (1966).
14. Shelton, J., Hollister, L. E. and Gocka, E. F., The Drinking Behavior Interview (An attempt to quantify Alcoholic Impairment), *Diseases of the Nervous System* 30, 464-467 (1969).
15. Smart, R. G., Are Alcoholics' Accidents Due Solely to Heavy Drinking? *Journal of Safety Research* 1, 70-73 (1969).
16. Smith, H. and Popham, R., Blood Alcohol Levels in Relation to Driving, *Canadian Medical Association Journal* 65, 325-328 (1951).
17. State of California, Transportation Agency. *The Roles of Carbon Monoxide, Alcohol, and Drugs in Fatal Single Car Accidents (Advanced Report).* Sacramento, California, 1965.
18. Waller, J. A., Use and Misuse of Alcoholic Beverages as a Factor in Motor Vehicle Accidents, *Public Health Reports* 81, 591-597 (1966).

Drinking Characteristics of DWI Individuals Screened as Problem Drinkers

Irwin Sandler[1], Sidney Palmer, Martin Holman, Robert Wynkoop

An accumulating body of literature indicates both that alcoholics have a disproportionately high prevalence rate of drunk driving offenses and that arrested drunk drivers have a disproportionately high tendency to be problem drinkers. Illustratively, Waller (5) investigated the police and community agency contacts of 150 males arrested for drunk driving in Oakland, California, and reported that almost two-thirds could be identified as problem drinkers. Selzer, Payne, Gifford and Kelly (3) conducted standardized interviews with 67 people arrested for drunk driving in Ann Arbor, Michigan and reported that 78% had pathological drinking problems.

These and similar findings have led to the suggestion that programs designed to reduce the recidivism rate of DWIs[2] need to intervene in the problem drinking behavior manifested by a large percentage of this population. Thus, the efforts of enforcement, judicial, and alcoholism rehabilitation systems are seen as complementary in attacking the social problem of the drunk driver.

The present paper reports on data collected in an assessment and referral program of DWIs in Phoenix, Arizona, who were screened as problem drinkers. These data contribute to the existing literature in the area in several important ways: (a) they report prevalence rates of a wide range of symptoms of problem drinking rather than simply classifying clients as problem drinkers or not problem drinkers; (b) they concern current drinking problem symptoms of selected DWI clients; and (c) they report drinking problem symptoms of clients screened as 'high risk' problem drinkers, thus having implications for the validity of a screening procedure to identify problem drinkers.

METHOD

Clients arrested for DWI in Phoenix, Arizona, were used as subjects. They were either convicted of DWI, or as a consequence of a plea bargain, convicted of a lesser charge and were referred to an educational program on drunk driving. Information collected consisted both of prior police records (prior number of DWI arrests), police records pertinent to the present DWI arrest (blood alcohol level, time of arrest) and a paper and pencil test battery (MAST (4), personality scales, other items related to problem drinking). Twenty-eight separate pieces of information were considered from these data to make a subjective decision to screen clients as 'high risk' problem drinkers. Approximately 37% of the total group were so identified. Clients screened as 'high risk' problem drinkers were referred to an interview for further assessment of their problem drinking behavior and were referred to a rehabilitation program. The subjects of the present study were 281 clients screened as 'high risk' problem drinkers over a five-month period.

---

[1] St. Luke's Hospital Medical Center, Phoenix, Arizona and Arizona State University, Tempe, Arizona, U.S.A.

[2] DWI = driving while intoxicated

The interview was conducted by one of three trained interviewers. It consisted of a structured series of questions exploring different aspects common to most definitions of alcoholism including: life adjustment problems related to alcohol, implicative drinking as assessed by an adaptation of Mulford and Miller's (1) preoccupation with alcohol scale, and Pattison's (2) drinking status scale, and self recognition of drinking problems. The 29 individual symptoms thus assessed were arbitrarily combined to form summary scores on client adjustment problems due to drinking (moderate and severe), client drinking pattern problems (moderate and severe), client recognition of his own drinking problem (moderate and severe) and an overall problem drinking summary score. All ratings were based on the client's report of present drinking problems, operationally defined as referring to the four-month period of time prior to the interview.

Reliability of the interviewer ratings on each of the 29 individual symptoms was established by having the three raters independently rate 24 tape recorded interviews. The mean percentage of agreement of all three raters across the 29 individual symptoms was 84.88 and the median percentage of three raters agreement was 90.90.

RESULTS

The age, sex, ethnic, marital, employment, and occupation status of the subjects are presented in Table I. Ninety per cent of the subjects were male; 85% were between 20 and 49 years of age; ethnically, over 60% were White Anglo Saxon, although there was a substantial (23%) percentage of Mexican-Americans; the majority were married, although over 30% were either divorced or separated; occupationally, the majority were engaged in blue collar work and although 73% were employed full time, a rather large number (18.5%) were unemployed.

The drinking problem characteristics as reported by the clients are presented in Table II. Almost 45% of the clients usually drank to a point of intoxication; almost 20% had an increased tolerance to alcohol; 45% drank for the effect of alcohol; 26% missed meals while drinking; 34% experienced blackouts; 17% drank in the morning; 14% had shakes in the morning after drinking and 11% had been intoxicated at work. Regarding the effect drinking had on their life adjustment, almost 25% said that drinking had adversely affected their health, over 50% reported an adverse effect on their family relationships from drinking, over 12% had some problems with their friendships from drinking and 16.7% had problems at work related to their drinking. In the area of their recognition of having a drinking problem, 22% considered themselves to be problem drinkers, 27% desired a major change in their drinking behavior and 22% wanted help to change their drinking behavior.

TABLE I *Demographic Characteristics of Clients Screened as High Risk Problem Drinkers (N = 281)*

Variable	N	%	Variable	N	%
Occupation			Ethnic		
Professional	4	1.4	White	173	61.6
Business	24	8.6	Black	19	6.8
Clerical/Sales	19	6.8	Mexican-American	66	23.5
Skilled labor	155	55.8	Indian	20	7.1
Unskilled labor	60	21.6	Other	3	1.1
Farmer	1	.4	Age		
Housewife	6	2.2	< 20	9	3.2
Student	8	2.9	20-29	101	35.9
Military	1	.4	30-39	77	27.4
Sex			40-49	61	21.8
Male	253	90.0	50-59	28	9.9
Female	28	10.0	> 60	5	1.8

TABLE II *Drinking Problem Characteristics of Screened "High Risk" DWIs (N=281)*

VARIABLES	N	%	VARIABLES	N	%
Usual Frequency of Drinking			Increased Tolerance		
No drinks/year	1	0.4	Yes	127	45.2
No drinks past two months	24	8.5	No	153	54.4
Only on occasions	25	8.9	Gulp Drinks		
Once a week/less	52	18.5	Yes	79	28.1
More than once/week	126	44.8	No	201	71.5
Daily	53	18.9	Neglect Meals		
Usual Intensity			Yes	74	26.3
Short of intoxication	155	55.2	No	206	73.3
Stops at intoxication	113	40.2	Drink Before Party		
Past intoxication	13	4.6	Yes	56	19.9
Usual Compulsivity			No	224	79.7
None	188	66.9	Supply Concerns		
Controls felt compulsivity	50	17.8	Yes	9	3.2
Compulsive episodes	28	10.0	No	271	96.4
Compulsive to binges	15	5.3	Black Out/Extreme Drinking		
Social Pattern			Yes	97	34.5
Only in social situations	113	40.2	No	182	64.8
Alone and socially	158	56.2	Black Out/Moderate Drinking		
Alone	10	3.6	Yes	26	9.3
C.N.S. Sequelae			No	253	90.0
None	157	55.9	Morning Drink		
One or more	124	44.1	Yes	49	17.4
Physical Sequelae			No	231	82.2
None	188	66.9	Shakes in Morning		
One or more	93	33.1	Yes	41	14.6
Psycho-social Sequelae			No	239	85.1
None	18	6.4	Work Intoxicated		
One or more	263	93.6	Yes	33	11.7
Health Effected by Drinking					

TABLE II *(Continued)*

VARIABLES	N	%
Serious	20	7.1
Moderate	35	12.5
None	212	75.4
Complicates existing health problem	13	4.6
Family Effected by Drinking		
Very serious	15	5.3
Serious	36	12.8
Moderate	93	33.1
None	135	48.0
Friendships Effected by Drinking		
Very serious	8	2.8
Serious	27	9.6
None	244	86.8
Work Effected by Drinking		
Very serious	7	2.5
Serious	8	2.8
Moderate	29	10.3
No problem	234	83.3
Desires Change/Pattern		
Major change	77	27.4
Change in pattern or style	81	28.8
Learn more	18	6.4
No change	92	32.7
Desires Help		
Wants help	64	22.8
Already changing	41	14.6
Change on own	38	13.5
Doesn't want help	102	36.3
Summary Scores		
Drinking Status Scale Total		
⩽6	130	46.2
>6	151	53.7
Moderate Adjustment Problems		
0	5	1.8
1	77	27.5
2	109	38.9
3	73	26.1
4	12	4.3
5	4	1.4
Severe Adjustment Problems		
0	164	58.6
1	86	30.7
2	20	7.1
3	7	2.5
4	2	.7
5	1	.4
Moderate Drinking Problems		
0	62	22.1
1	54	19.3
2	50	17.9
3	35	12.5
4	32	11.4
5	24	8.6
6	18	6.4
7	4	1.4
8	1	0.4
9	0	0.0
No	245	87.2
Sneak Drinks		
Yes	17	6.0
No	263	93.6
Worry About Getting Drinks		
Yes	16	5.7
No	264	94.0
Binge		
Yes	19	6.8
No	261	92.9
Problem Drinker – self rating		
Yes	63	22.4
Uncertain	30	10.7
No	186	66.2
Total Adjustment Problems		
0	3	1.1
1	41	14.6
2	66	23.6
3	72	25.7
4	40	14.3
5	28	10.0
6	14	5.0
7	8	2.9
8	2	.7
9	4	1.4
10	1	.4
11	1	.4
Total Drinking Problems		
0	45	16.1
1	27	9.6
2	32	11.4
3	27	9.6
4	28	10.0
5	17	6.1
6	13	4.6
7	18	6.4
8	16	5.7
9	18	2.9
10	9	3.2
11	7	2.5
12	4	1.4
13	3	1.1
14	1	.4
15	2	.7
16	4	1.4
17	3	1.1
18	7	2.5
19	3	1.1
20	1	.4
21	1	.4
22	2	.7
23	1	.4
24	0	.0
25	0	.0
26	1	.4

TABLE II *(Continued)*

VARIABLES	N	%	VARIABLES	N	%
Severe Drinking Problems			Total Recognition of Problems		
0	109	38.9	0	89	31.8
1	73	26.1	1	29	10.4
2	41	14.6	2	47	16.8
3	23	8.2	3	45	16.1
4	7	2.5	4	20	7.1
5	4	1.4	5	22	7.9
6	14	5.0	6	28	10.0
7	3	1.1	Total Problem Summary Score		
8	5	1.8	0	2	.7
9	1	.4	1	9	3.2
Moderate Recognition of Problems			2	13	4.6
0	136	48.6	3	18	6.4
1	88	31.4	4	16	5.7
2	48	17.1	5	23	8.2
3	8	2.9	6	17	6.1
			7	20	7.1
Severe Recognition of Problems			8	23	8.2
0	161	57.5	9	18	6.4
1	62	22.1	10	14	5.0
2	29	10.4	11	15	5.4
3	28	10.0	12	9	3.2
			13	7	2.5
			14	8	2.9
			15	68	24.0

The drinking problems of these selected DWIs are even more clearly demonstrated by the summary scores. A total problem summary score cut-off point of 5 or greater was arbitrarily established as a criterion for classifying a problem drinker. The summary score was arrived at by classifying problems as moderate (weighted 1) or severe (rated 2) and summing across the 29 individual items. Thus, in order to achieve a total score of 5 or more, a client would need to report at least 5 moderate problems, 3 moderate and 1 severe problem, or 2 severe and 1 moderate problem. Approximately 80% of the clients scored above the cut-off point for problem drinkers.

DISCUSSION

Several aspects of the data are particularly worthy of emphasis.

1. The problem drinking characteristics reported refer to presently experienced problems, occurring over the four-months prior to the interview.

2. The sample assessed is a screened sample, selected as a 'high risk' problem drinking group from clients arrested for DWI. The high rate of problems found in this 'high risk' group indicate that these DWI individuals are indeed appropriate for rehabilitation for drinking problems. The contrast between the approximately 20% rate of self-assessment as a problem drinker and the 80% classified as problem drinkers on the summary scores however, indicates that motivation of the problem drinking driver to recognize and begin to deal with his problem drinking behavior may be one of the great challenges faced by rehabilitation programs working with this population.

REFERENCES

1. Mulford, H. A. and Miller, D. E., Drinking in Iowa, IV. Preoccupation with Alcohol and Definitions of Alcohol Heavy Drinking and Trouble Due to Drinking. *Quarterly Journal of Studies on Alcohol* 21, 279-291 (1960).
2. Patterson, E. M., Headley, E. B., Gleser, G. C., and Gottschalk, L. A., Abstinence and Normal Drinking: an Assessment of Changes in Drinking Patterns in Alcoholics after Treatment. *Quarterly Journal of Studies on Alcohol* 29, 610-633 (1968).
3. Selzer, M. L., Payne, C. E., Gifford, J. D., and Kelly, W. L., Alcoholism, Mental Illness and the Drunk Driver. *American Journal of Psychiatry* 120, 326-331 (1963).
4. Selzer, M. L., The Michigan Alcoholism Screening Test: The Quest for a New Diagnostic Instrument, *American Journal of Psychiatry* 127, 1653-1658 (1971).
5. Waller, J. A., Identification of Problem Drinking among Drunk Drivers. *Journal of the American Medical Association* 200, 114-120 (1967).

The Drinking Driver: Identification of High-Risk Alcoholics

Paul F. Zelhart, Jr., Bryce C. Schurr[1,2] and Peggy A. Brown

National statistics on traffic safety repeatedly show the drinking driver to be implicated in automobile accidents and traffic fatalities. 'Alcoholics' are grossly overrepresented among impaired drivers (8, 20) and among those drivers responsible for automotive accidents and fatalities (12, 16, 17, 18). Thus the alcoholic driver provides a serious threat to himself and to the rest of the driving population.

While a number of studies have isolated apparent personality traits of alcoholics (1, 4, 7, 10), relatively little research has been done to attempt to relate those characteristics to the driving behavior of alcoholics possessing such characteristics.

Psychiatric studies have demonstrated that alcoholics tend to be more aggressive, hostile, and self-destructive than control subjects (13, 15), and thereby confirm the relationship between prolonged abuse of alcohol and a psychopathology. However, as Schmidt and Smart have noted (16), this evidence does little to establish the causal relationship between enduring personality traits and the occurrence of traffic accidents.

A more direct relationship between the personality of alcoholics and their driving behavior was found by Zelhart (19). The citation histories of groups of alcoholics, identified by Lawlis and Rubin (7), were compared to determine the extent to which personality was related to dangerous driving habits. The Ss with significantly lower frequencies of citations were among the group which had been described as "inhibited or maladaptive, and frustrated," while the Ss with a greater frequency of citations were from the group identified as "unsocialized and aggressive". Such a finding, although based upon a rather small sample size, and dealing only with a population of identified alcoholics, seems to provide direct support for Selzer's study (13) but also points to the possibility that not all alcoholics represent the same degree of highway hazard.

Progress towards implementing countermeasure programs would be greatly improved if independent and objective measures could identify drivers representing risks

---

[1] Applied Psychology Unit, Department of Psychology, University of Alberta, Canada.

[2] This research was partially supported through funds granted by the Ministry of Transport, Ottawa, Canada ("Basic Research into the Drinking-driving Problem," 1974) and the Summer Temporary Employment Program of the Province of Alberta (T617B – Department of Highways, 1973). In addition, the authors acknowledge the assistance and cooperation of the Alberta Alcoholism and Drug Abuse Commission, Alberta Impaired Drivers' Program, Alberta Department of Highways, Driver Review Board, Alberta Department of the Attorney General and Division K of the Royal Canadian Mounted Police in the collection of the data.

to highway safety. Present systems do not appear to offer effective prediction of hazardous drivers. In many jurisdictions an individual is not assumed to have a problem with alcohol until his second conviction for impaired driving. Two convictions may well indicate alcoholism. Nevertheless, nearly 88% of the highway fatalities involving drinking drivers cannot be isolated by the prior occurrence of impaired driving convictions (12). Thus independent indices must be developed. To this end, the present study attempts to determine any personality characteristics that may be related to dangerous behavior and to the prediction of highway hazard.

Previous evidence identifies the driver who is impaired by alcohol as representing the greatest risk to highway safety not only in terms of his involvement in automobile accidents but with respect to the incidence of "reckless" driving and excessive speed citations (3). Yet there is another group of drivers whose records indicate imprudent driving behavior and an increased safety risk but who have avoided, either through judicious drinking-driving behavior or fortuitous circumstances, prior conviction for (alcohol) impaired driving. These we have defined as high-risk drivers.

The purported prevalence of alcoholism among impaired drivers suggests the occurrence of another group of drivers offering a threat to highway safety. This group is composed of individuals who consume beverage alcohol in sufficient quantities and behave in such a way as to be classified as alcoholics. Of that group there are those who have avoided conviction for dangerous or impaired driving. That is, they are alcoholics who, when drinking, were prudent enough to avoid driving or took other precautions so as not to draw the attention of the police.

Finally, there is a group representative of the vast majority of the driving population. These are drivers who consume beverage alcohol but who would not be classified as alcoholic and who have histories of safe driving behavior. Such individuals are of interest because they are exposed to the toxic effects of alcohol yet do not manifest the behavioral symptoms of either the alcoholic or the driver presenting a highway hazard.

METHOD

Subjects

Five groups of subjects, representing varying degrees of highway hazard and involvement with alcoholic beverages were employed in this study. The members of all groups were males who possessed a currently valid Alberta Operator's License.

Group ID. This group consisted of a sample of 201 convicted impaired drivers participating in the Alberta Impaired Drivers' Program(AIDP).

Group HR. A group of 200 high-risk drivers was obtained through interviews conducted by the Driver Review Board of the Alberta Department of Highways. The subjects of group HR had accumulated 9 to 14 Highway Traffic Act demerit points in the 24 months preceding their interview but had no alcohol-related accident or conviction for impaired driving.

Group AL. This group consisted of a sample of institutionalized alcoholics obtained through the Alberta Alcoholism and Drug Abuse Commission's Henwood Treatment Facility and Outpatient Clinic. After interviewing some 950 clients, the staff was able to isolate 58 who had never been cited for impaired driving and whose records showed no moving violations or traffic accidents during the preceding 24 months.

Group CN. The members of this group and of the remaining group CA were volunteers from Division K of the Royal Canadian Mounted Police and the Alberta Attorney General's office. The men were assigned to one of these two groups according to their responses to mailed questionnaires and the Michigan Alcoholism Screening Test (MAST, 14). Group CN (N=140) were "normal social drinkers" or non-drinkers, and scored less than 4 on the MAST.

Group CA. The subjects assigned to group CA (N=49) were reported "regular and frequent" consumers of alcohol and exceeded the performance criterion "suggestive of alcoholism" on the MAST.

Subjects in Groups CN and CA were all safe drivers as indicated by a citation- and accident-free record in the 36 months preceding their participation in the project.

Test Materials

Each S completed a 40-item Personal Information Questionnaire (PIQ) designed as the basic socio-demographic instrument of the AIDP. The questions assessed the major socio-demographic attributes of the respondent in addition to eliciting a self-report of his prior involvement with beverage alcohol and previous encounters with legal authorities. In addition, each S completed the Howarth Personality Questionnaire (HPQ, 6) and the Psychoticism, Extroversion and Neuroticism Inventory (PEN; Eysenk[3]). Responses to the MAST were obtained from all groups with the exception of group HR, where time limitations of the interview made its administration impractical. For the purpose of the present study the final two questions of the MAST, which deal specifically with prior alcohol-related arrests, were eliminated in scoring the S's responses.

RESULTS

Major Socio-Demographic Attributes

Several interesting, and in some cases surprising, results from the PIQ appeared, and these require attention. In general, the groups were less different on major socio-demographic indices than had been expected. Virtually all were Caucasian (at least 89% in each group), and from a Christian faith. The majority were married and living with their first wife at the time of the interview. Only alcoholics under treatment (Group AL) showed a marked incidence of divorce or separation (31.2%). While the younger driver was somewhat overrepresented among Groups ID and HR, the mean age of the Ss was 37 years and failed to differ significantly among the groups. At least two-thirds of the Ss in each group had completed a minimum of nine years of education and more than one-half had completed some portion of high school.

The groups did differ, however, with respect to their Social Economic Standing (SES) as determined by Hollingshead's Two-Factor Index of Social Position (5). While all other groups were identified as representing the 'middle class' (Class III), the mean SES score for Group ID placed them within Class IV ('lower middle'). An analysis of variance of the SES scores evidenced the significant effect between groups ($F = 25.25$, $df = 4, 587$, $p < .001$) and post hoc comparisons identified further differences among the 'middle class' groups. While the Ss in Group ID had significantly higher SES scores (*i.e.*, lower social standing) than all other groups, Groups CN and CA had significantly lower mean scores than Groups HR and AL ($p < .05$). In fact, the mean SES scores for

---

[3] Personal communication, Sybil Eysenck, 1972.

Groups HR and AL were closer to the classification of being from the 'lower middle' than the 'middle' class. This is not particularly surprising due to the nature of the jobs held by the members of Groups CN and CA.

Before proceeding with the discussion of the Ss' responses to questions dealing with their use of beverage alcohol and prior arrests a word of caution is necessary. While the incidence of failing to respond to innocuous questions on the PIQ was relatively low, a large number of Ss avoided responding to items which dealt with their use of beverage alcohol: in some cases as many as 17% of the Ss overall. Regardless of the multitude of reasons which may be responsible for this, failure to respond makes interpretation difficult and conclusions tenuous. In addition, with this type of instrument, we inherently trust the veracity of the S's report. However, the work of Pinneau and Melton (11) shows that when questions relate to behavior which may be seen as socially deviant or carries social and legal sanctions, greater caution must be exercised in assessing self-report data. It was not feasible, and in many cases impossible, for us to search the numerous official records to validate a S's responses. Thus, in the following discussion, we present several interesting reports by our Ss which were not independently confirmed and thus remain the Ss' reports.

Patterns of Drinking Behavior

We asked the Ss how old they were when they had their first drinking experience and their responses are shown in Figure 1. With the exception of Group CN, which contained a number of "non-drinkers," at least 73% of the Ss reported using alcohol prior to their 21st birthday. A substantially greater proportion of the high-risk drivers (Group HR, 33%) than the alcoholics under treatment (Group AL, 14%) reported having consumed alcoholic beverages before the age of 15 years. Interestingly, the least frequent incidence of reported teenage drinking was among the convicted impaired drivers (Group ID, 8%).

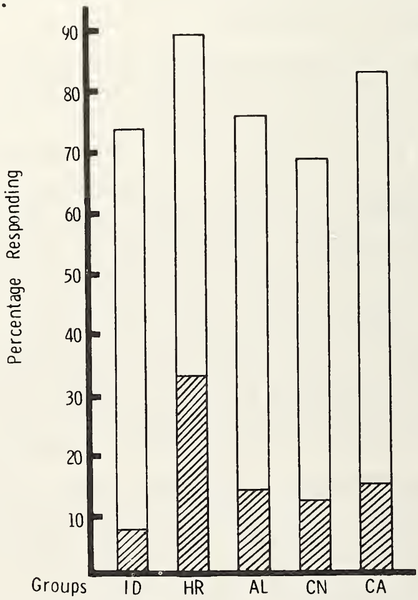


Figure 1 *Age of First Drinking Experience. The Unfilled Bars Represent Responses 'Prior to 21st Birthday' and the Filled Bars 'Prior to 15th Birthday'.*

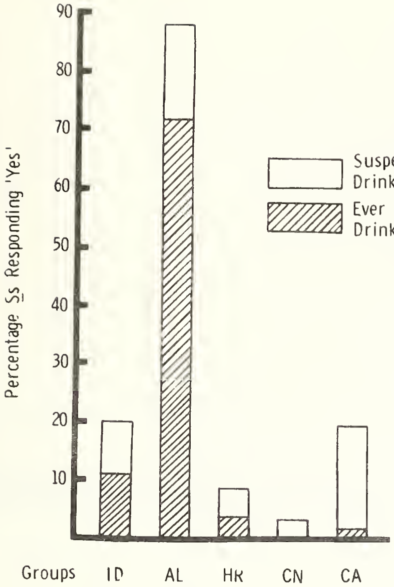


Figure 2 *Percentage of Ss Responding 'Yes' to Questions of 'Suspected Drinking Problem' (Unfilled Bars) and 'Sought Help for Problem' (Filled Bars).*

When asked if they "suspected they might have a drinking problem" the vast majority of the alcoholics under treatment (Group AL) responded affirmatively (Figure 2). Far fewer of the Ss in Groups CN (2.9%) and HR (8.5%) reported a suspected drinking problem than did the Ss in Group ID (19.9%) and Group CA (19.1%). This is interesting since the latter groups would be classified as "suspected alcoholics" by means of the MAST. Although 19% of all the Ss reported a suspected drinking problem, only 11% reported ever having "sought help" for their problem from any source whether it were A.A., medical doctors, clergy or family. Eighty-eight per cent of the alcoholics under treatment reported a suspected drinking problem. The lack of unanimity among the Ss was somewhat surprising since all were participating in an alcohol treatment program at the time they were questioned.

Figure 3 shows marked differences among the groups with respect to the reported "daily consumption of alcohol." While one-half of the Ss in the control-normal (Group CN, 50.4%) and the high-risk group (Group HR, 46.2%) reported consuming not more than 3 drinks in a "normal drinking day," 38.8% of the Ss in Groups ID and CA reportedly consumed more than six drinks daily. This rate was easily exceeded by the alcoholics under treatment where 80% of the Ss reported consuming more than six drinks in a drinking day. While this rate of consumption was greater among the high-risk drivers (24.3%) than in the control-normal group (16.2%), the reported frequency of excessive alcohol consumption remains far less than for groups with suspected or confirmed alcohol dependencies. By and large, the alcoholics under treatment showed the most excessive daily consumption of alcohol. The reported patterns among the Ss in Groups ID and CA appeared similar but distinct from those of Groups HR and CN.

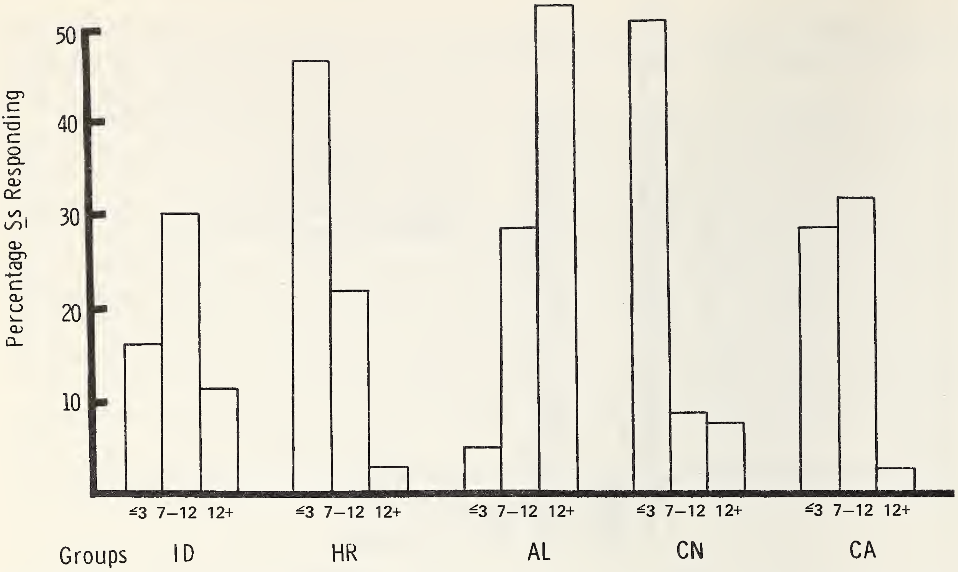


Figure 3 *Consumption of Beverage Alcohol (Drinks or Beers) in a 'Normal Drinking Day'. Percentages Based on the Samples of Ss Responding to the Question.*

Although the convicted impaired drivers reported a greater daily consumption of beverage alcohol than did the high-risk drivers, the frequency of "drinking days per week" was not dramatically different between the groups, as can be seen in Figure 4. Sixty-four per cent of Group ID, 57.5% of Group CA and 55.9% of Group HR reported consuming alcohol on no more than two days during the week. The only group demonstrating a positive relationship between the frequency of consumption and the amount consumed was the AL Group, where 77.6% reported at least five drinking days during the week. However, the Ss in Group CN again showed considerable moderation in their pattern of alcohol consumption.

Clearly, alcoholics under treatment are distinguished from all other groups on the basis of their excessive involvement with alcohol. What appears to distinguish the alcohol impaired drivers from the high-risk drivers was not the frequency with which they consumed beverage alcohol but the differential quantities consumed when they did drink. Thus, it would seem that while high-risk drivers may have attempted to operate motor vehicles after drinking as frequently as impaired drivers, the impaired drivers may be more readily identified because they are impaired to a greater extent.

Indices of Alcohol Dependency

Some of the traditional indices of alcohol dependency are: objections among family members to the individual's drinking behavior, the loss of employment as the result of his drinking and the occurrence of "blackouts". The responses of the Ss to these questions are provided in Figure 5. When we asked Ss about family objections nearly twice the proportion of the impaired drivers (30.0%) confirmed a family conflict over their drinking than did the Ss in the high-risk drivers group (16.7%). In addition, a

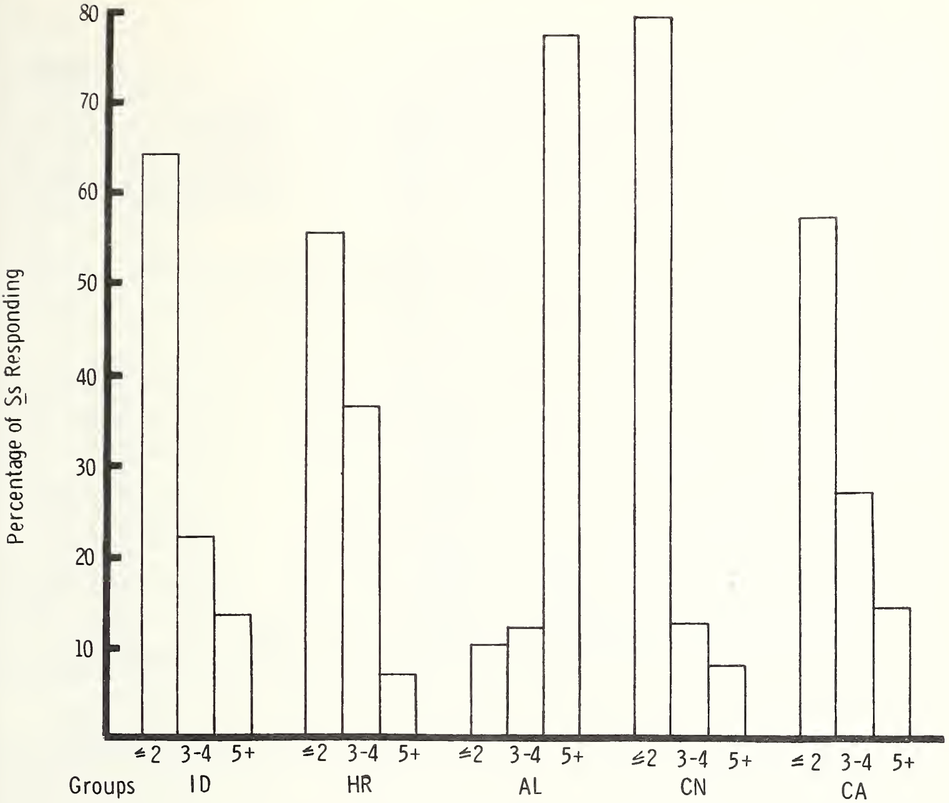


Figure 4 *Frequencies of 'Normal Drinking Days/Week'. Percentages Based on the Samples of Ss Responding to Question.*

substantial proportion (20%) of the Ss in Group CA responded positively to this question. The incidences, however, did not approach those of Group AL. As would be expected, the incidence of family conflicts over drinking was the lowest in Group CN (2.2%). The only group to reportedly have had a substantial incidence of loss of employment due to drinking was the alcoholics under treatment (36.7%). This may be one important factor in an individual's identification of a problem with alcohol consumption. Group AL also reported the largest incidence of "blackout" (82.5%). However, nearly twice the proportion of Ss in Group CA (44%) indicated that they had experienced "blackout" than did the impaired drivers (23.9%). The lowest reported incidence was among the high-risk drivers (13.6%) and the control-normal group (6.6%).

The Ss in Group AL appeared to be distinguishable from all other groups, not only in terms of their (previous) involvement with beverage alcohol but also, by the traditional indices of chronic alcohol dependency. For the other groups, however, there was not a consistent pattern among these data, except among the control-normal sample, who consistently demonstrated the least frequent indicators of alcoholism. Although impaired drivers and control-alcoholics demonstrated similar patterns of drinking behavior, they were not easily distinguished from the Ss in Group HR, who might be suspected of an alcohol problem but had not yet evidenced it through their driving behavior.

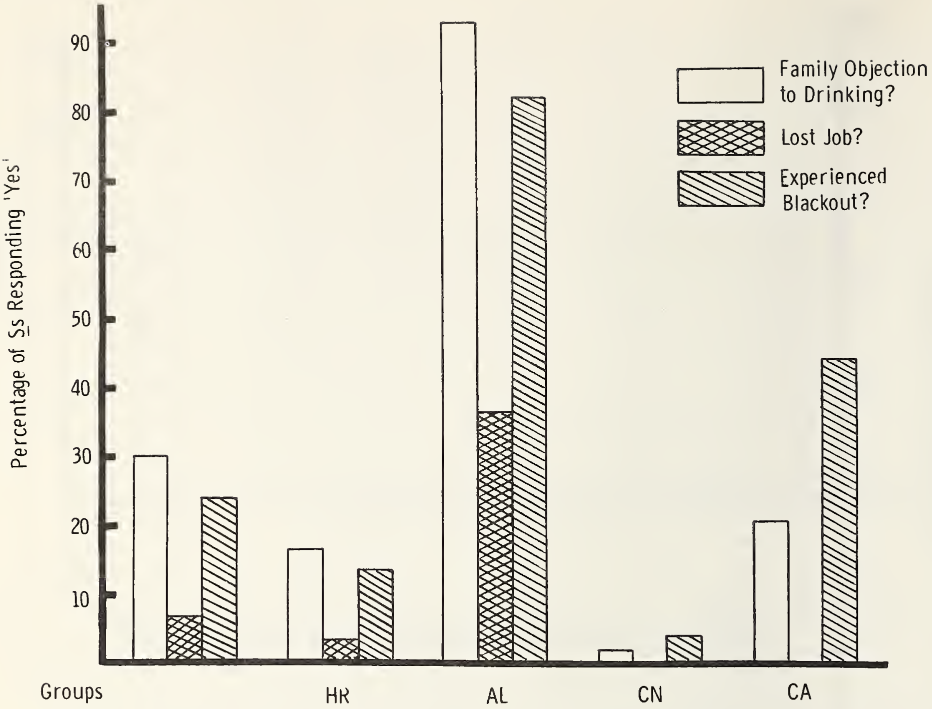


Figure 5 *Percentage Affirmative Responses to Traditional Indices of Alcohol Dependency.*

Prior Arrests

The Ss were asked the number of times they had been arrested by a police officer and the number of times they had been arrested on alcohol-related offences. No impaired driver was arrest-free: 43.3% had a single arrest (*i.e.*, for driving while impaired by alcohol) 29.8% of the Ss had three or more arrests. For 23.4% of the impaired drivers there had been three or more alcohol-related arrests. Virtually all of the high-risk Ss (84.1%), control-normal Ss (98.5%) and the control-alcoholic Ss (95.7%) had never been arrested. Among the alcoholics under treatment 54.6% of the Ss had been arrested at least once and 40% on at least one alcohol-related offence; but not alcohol impaired driving. Seventeen per cent of Group AL had three or more alcohol-related arrests.

One variable distinguishing the Group ID from Group AL appeared to be their involvement with legal authorities over their use of beverage alcohol. Although the alcoholics tended to have used beverage alcohol more excessively than the impaired drivers, they reported that they had less contact with the legal authorities. In addition, the incidence of alcohol-related arrests among high-risk drivers suggested that the impaired driver may be distinguished from the former groups, not only in terms of their consumption of alcoholic beverages, but in terms of what he does after excessive drinking. While the high-risk drivers and the alcoholics under treatment may have reached similar degrees of impairment as the result of their drinking, the former apparently avoided contact with the legal authorities while impaired.

Personality Data

Mean scores on the four scales of the PEN and the 10 scales of the HPQ are presented for the five groups of Ss in Table I. In general, the greater the value of any of the scales the more predominant the traits associated with the scale are within the personality of the S[4]. However, the absolute value associated with the scale must be taken with respect to some underlying value within the general population; *i.e.,* the normative value for the scale.

TABLE 1 *PEN and HPQ Group Mean Scores*

Group	PEN Factors			HPQ Factors										
	E	N	P	Sy	AE	AD	SG	HM	IP	CC	IF	PS	TS	n
Control:normal (CN)	12.70	3.93	.94	6.76	2.55	5.12	8.43	2.18	2.42	9.22	2.08	9.22	5.14	140
Control:alcoholic (CA)	11.41	6.20	1.31	5.92	4.16	5.10	8.49	3.45	2.78	8.63	2.84	8.57	5.41	49
AIDP (ID)	12.77	5.63	1.63	7.60	3.77	4.38	6.83	3.24	3.99	8.24	3.21	8.31	6.18	201
Alcoholics under Treatment (AL)	9.79	13.00	3.98	4.94	8.31	5.50	7.17	6.81	5.17	7.66	6.69	5.84	6.78	58
High-Risk Drivers (HR)	13.46	5.43	1.97	8.07	3.12	5.78	6.77	2.58	3.66	8.15	2.13	8.61	6.05	189
Grand Mean	12.59	5.91	1.77	7.19	3.75	5.12	7.32	3.15	3.56	8.41	2.93	8.39	5.88	637
Canadian Norms[a]	Male University Students –			7.52	4.86	5.88	5.01	3.67	4.35	7.98	3.68	7.37	6.30	
	Male Soldiers –			8.85	3.84	5.33	7.49	3.37	4.26	9.13	2.65	8.53	6.76	

[a]Mean Canadian norms for the HPQ from Howarth (6)

The scores of Ss within Group CN differed from the norms of Canadian University students (males) on two dimensions of the HPQ but were consistent with the norms for Canadian soldiers on all dimensions. On the scales labeled Super Ego (SG) and Cooperativeness-Considerateness (CC) these Ss were at least one standard deviation (sd) higher than the norm for the University students. They were, however, somewhat lower than the norm on the Adjustment-Emotionality (AE) scale.

Control Ss who drank more frequently (Group CA) scored lower than both normative samples on the Sociability (Sy) scale of the HPQ and higher on the the SG scale than the Canadian University students. Virtually no differences were found when the profiles of the impaired drivers (Group ID) were compared with the Canadian norms.

The mean scores for Group AL differed from the norms on a number of scales. They were far less sociable (Sy) and more "neurotic" than army personnel and they tended to be more hypochondriacal (HM) than both students and soldiers. They also scored higher on the Inferiority scale (IF) and lower on the Persistence scale (PS) than the soldiers. The Ss in Group AL appeared to have a group personality profile which showed a considerable amount of pathology. From their performance on the HPQ, they were characterized as withdrawn, neurotic, and anxious with feelings of inferiority and inability to maintain directionality in life or work.

Although there are no separate Canadian norms, normative data for the PEN were available for various groups; *i.e.,* students, psychotics and neurotics. Comparing the profiles of our groups with the students' norms, it was clear that the current samples were not unusual in terms of the Extroversion scale (E); all groups were within one sd of the male student norms. Comparisons on the Neuroticism (N) scale showed

---

[4] A description of the personality attributes associated with these scales is provided in Appendix A.

Group CN to be a full sd below the norms of the students and the least "neurotic" of the present groups. On the other hand, the Ss in Group AL were the most "neurotic," with the group mean higher than, but within one sd of the norm for neurotics. The mean scores of Groups ID, HR and CA did not suggest neuroticism as an important trait. Only group AL scored highly on the Psychoticism (P) scale of the PEN. Their mean score was within one sd of the neurotics' and psychotics' norm. The remaining groups were well within the lower range of the normative university sample.

In summary, a clinical analysis of the personality profiles of the various groups revealed that only the Ss in Group AL presented a marked pathology. In terms of their responses to the HPQ and the PEN, these Ss appear to be highly neurotic. The group profiles of the other samples are well within the limits of 'normal' personality attributes.

Discrimination Among Groups of Drivers

The method of multiple discriminant analysis attempts to derive one or more sets of weighted, linear functions of variables which have the maximum potential of discriminating among the members of different a priori groups of Ss. Each set of weighted combinations of the original variables, *i.e.*, discriminant functions, maximizes the variance between the groups relative to the pooled within-groups variance among the original variables while maintaining independence (orthogonality) between the functions.[5]

Having determined the linear functions that maximize the difference among the group means of the original variables, a procedure of classifying Ss, or determining the a priori group to which each S most likely belongs, may be performed. The effectiveness of the discriminant functions in providing adequate separation among the groups is assessed by means of the errors in classification. The less often Ss are misclassified the more effective the functions are in isolating the groups. In addition, the degree of correct classification indicates the extent to which the a priori groups represent distinct collections of Ss within the general populations with respect to the dependent measures taken. Although the classification functions may maximally separate the groups, errors in classification may be substantial. Under these circumstances, not only is the ability to distinguish among the Ss of the a priori groups reduced but it is likely that variance within the groups is sufficient to provide a significant overlap between the subsets of the population.

The principal goal of employing discriminant analysis in the present study was to isolate a set of test scores (or scales) which would separate and identify the members of the present groups. Because of this, and due to a high degree of dependence among certain of the test scales, it was decided to employ a procedure which would allow for the selection of test scales that had the ability to maximize the group differences. To this end the scale scores for each of the Ss on the PEN and HPQ were submitted to a stepwise discriminant analysis.[6]

---

[5] An alternative manner of viewing the discriminant function is in terms of a cannonical variate which maximizes the squared deviations among group centroids relative to the within-groups variance (2, 9).

[6] The analysis was conducted at Computing Services, University of Alberta and employed the use of BMD07M, Stepwise Discriminant Analysis from the Biomedical Computer Program Library (University of California, Los Angeles, 1972).

The characteristics distinguishing a stepwise discriminant from its standard analytic form are in the manner of incorporating tests within the discriminant functions. For the purposes of the present analysis, the first variable selected maximized the difference among the groups having the most similar centroids. The second and succeeding variables were selected such that they maximized the minimal group difference remaining after previous variables had entered the discriminant functions. The process was continued until none of the remaining variables had the ability to distinguish significantly among the groups[7]. Having satisfied the criteria limiting the addition of variables, the Ss were then classified as members of one of the a priori groups on the basis of the degree of 'similarity' among their weighted test scales and the group centroid.[8]

Of the original 14 personality scales, 6 were required to maximally differentiate among the groups. The variables entering the final discriminant function were the SG, IF, Sy, TS and AD scales of the HPQ and the N scale of the PEN. Table II provides the coefficients of the group classification functions which, among other things, indicate the 'contribution' of the particular scale to the discrimination of any one group from all others and the weighting provided to the S's scores in the classification to that group.

TABLE II *Coefficients of Group Classification (Discriminant) Functions*

	Group				
Variables	ID	AL	HR	CN	CA
N 1	.259	.758	.301	.264	.428
SG 2	1.647	2.008	1.645	1.953	2.042
IF 3	.852	1.270	.652	.701	.719
Sy 4	.890	.691	.859	.718	.653
TS 5	.562	.134	.551	.426	.354
AD 6	.496	.838	.655	.657	.687
Constant	–15.078	–23.240	–15.325	–16.181	–18.226

By and large, the responses of the Ss on the SG scale of the HPQ contributed most to the classification functions of all the groups, although the N scale of the the PEN showed the greatest ability to differentiate among the least different groups. The reason for this appears to be in the discrimination of the alcoholics under treatment from the remaining groups. While the classification function for each of the remaining groups did not differ noticeably, the function for Group AL demonstrated a markedly distinct pattern. Far greater weight was given to scales relating to fear, feelings of inferiority and suspicion for this group than for any of the others. This was particularly true for the IF and AD scales of the HPQ and the N scale of the PEN.

Performance on the SG, IF and Sy scales of the HPQ were the greatest contributors to the classification of Ss as impaired drivers. While there was less effect of the responses to the items on the IF scale in the classification of high-risk drivers, the relative contribution of the AD scale was enhanced over that of Group ID. However, the functions for Groups CN and CA did not appear to be markedly different from that of Group HR except in the contribution of scores on the SG scale of the HPQ.

---

[7] Conditions established on the inclusion and/or exclusion of variables were: F-ratio to enter = 5.0, to remove = 4.9 ($p < .001$, df = 4, 600) and a priori assignment probabilities = 1/Ni.

[8] A summary of this analysis is provided in Appendix B.

Tables III and IV provide an indication of the ability of the group discriminant functions to distinguish among the a priori groups. The values of Table III show the tests of the equality of the centroids between pairs of groups. As in the univariate F-ratio, as the value increases the group centroids become more dissimilar. It is apparent that the weighted mean vectors for the groups differed significantly. If there were a degree of similarity, it existed between Groups CN and CA. The greatest differences appeared in the comparisons of the alcoholics under treatment with the other groups. The mean vectors of Groups ID and HR demonstrated striking differences when compared with that of Group CN.

TABLE III *F-Statistic for Equality of Group Centroids*[a]

Groups	ID	AL	HR	CN
AC	44.03			
HR	6.74	48.36		
CN	14.70	45.07	11.67	
CA	9.77	18.16	8.84	2.51

[a] $F(6,627) > 2.10$ ($p = .05$); > 2.80 ($p = .01$)

It should be recalled that the discriminant functions differentiate among the groups in terms of the centroids or mean vectors of original test scores. Although the centroids may be made significantly different by linear transformation, there may be sufficient overlap among the distributions of the groups to produce errors in classification. That is, while the average performance of the Ss may be sufficient to distinguish among the a priori groups, the dispersion about the group centroid may be great enough to interfere with correct classification. The classificatory ability of the discriminant functions is represented by the 'hit-rate' or the proportion of Ss 'correctly' assigned to the appropriate group. As the hit-rate increases there is greater evidence of the distinctiveness of the groups and the reliability of the discriminant functions. Alternatively, a high hit-rate may indicate the validity of the assumption of a priori groups being distinguished by the battery of tests included. Table IV provides the classification matrix produced in this analysis.

TABLE IV *Classification of Ss to A Priori Groups*

	Frequency of Ss assigned to Groups					
Original Group	ID	AL	HR	CN	CA	Hit-Rate
ID	106	10	55	29	1	52.7%
AL	7	43	3	4	1	74.1%
HR	58	7	86	38	0	45.5%
CN	34	6	34	66	0	47.1%
CA	9	6	14	20	0	0%
						(47.9%)

Except for the alcoholics under treatment, there is little evidence to indicate that Ss within the groups could be effectively distinguished on the basis of the selected factors of the PEN and the HPQ. Indeed, there *is* a high degree of misclassification (*i.e.,* confusion resulting from similarity in test performance) among the high-risk and convicted impaired drivers: nearly 31% of the Ss in Group HR (high-risk) were misclassified as members of Group ID and 28% of these (impaired drivers) were erroneously classified as high-risk drivers. It is interesting to note that only two of the 637 Ss were classified as members of the CA group and that Ss within that a priori group were most likely to be assigned to the HR or CN groups. On the other hand, the Ss within the CN group were most likely to be misclassified as either members of Group ID or HR. It is clear that, with the exception of the alcoholics under treatment, there was a high degree of overlap among the personality dimensions of the Ss, although the group means differed significantly. Moreover, the results suggest that it may be impossible to distinguish among groups of Ss who differed in their use of beverage alcohol and driving behavior by means of personality profiles. That is, the tests are insensitive to the differences among groups which demonstrated different behavioral indices of alcohol dependency and highway hazard.

On the other hand, the discriminant analysis may be isolating groups on the basis of a factor which has been ignored. One possibility lies in the extent of alcohol involvement among the Ss within the groups. It is conceivable that this may be evidenced in their personality profiles. In order to assess this possibility, the mean MAST scores were computed for the groups according to the classification of Ss by the analysis. These data are presented in Table V.

TABLE V *Mean MAST Scores of Original Groups and as a Function of Classification by Discriminant Analysis*

	Ss Assigned to Groups					
Original Groups	ID	HR	AL	CN	CA	Mean
ID	9.37 *106*[a]	7.07 *55*	13.30 *10*	4.65 *29*	8.0 *1*	8.18
AL	29.43 *7*	35.33 *3*	34.56 *43*	28.5 *4*	49.0 *1*	33.81
CN	1.06 *34*	1.59 *34*	1.00 *6*	1.49 *66*	*0*	1.37
CA	6.66 *9*	7.29 *14*	11.00 *6*	7.20 *20*	*0*	7.59
Mean[b]	8.30	6.14	24.87	4.13	28.5	

[a] Numbers in italics are n's within cell.
[b] Excludes high-risk drivers where MAST was not available.

The means of the rows indicate the average MAST scores of the a priori groups, while the means of the columns are the averages for the Ss classified as being "most similar" to the a priori group. One would expect that the MAST scores of the alcoholics under treatment would be greater than all other groups and that impaired drivers would score higher than either of the control samples. This prediction was upheld for the a priori groups as well as for the classification groups identified in the analysis. The only exception was in assigning Ss to Group CA, but this was probably due to the low frequency of assignment.

All Ss assigned to Group AL had the highest MAST scores except among the original CN Ss; resulting from our original selection criteria. The results were, however, not consistent within all of the remaining groups. The expected pattern was noted among the original HR group but, for Groups AL and CA, the Ss assigned to Group HR scored higher on the MAST than those assigned to Group ID. In addition, there was little difference between the means of the AL Ss classified as members of the ID or CN groups. This seems to confirm our suspicion that the personality tests were incapable of correctly isolating Ss on the basis of their prior driving behavior or involvement with alcohol. The exception to this is in the case of Ss whose involvement with alcohol was probably at an extreme.

DISCUSSION

The strategy adopted in the current project was to draw samples of Ss from various a priori groups of drivers and to compare their demographic and personality characteristics. The type of information obtained from such a strategy depends, to a great extent, upon the astuteness with which the a priori groups are selected. Numerous other groups of Ss could have been examined in addition to the five groups which were selected. In addition, the criteria identifying members of particular groups might be re-examined with the aid of hindsight. For instance, one might use some measure other than accumulated demerit points as a criterion of the high-risk drivers. Regardless, the current report provides important, if not definitive, information concerning the demographic and personality characteristics of the selected groups.

Demographic Characteristics of the Groups

Two of the five groups (Groups ID and HR) represented individuals contributing to major highway safety problems. While both groups shared some common characteristics, they tended to differ markedly on a number of aspects. The high-risk drivers tended to be somewhat better educated, to have first consumed alcohol at an earlier age and, although they consumed alcohol as frequently, they tended to drink less than the group of impaired drivers. Sixty per cent of the Ss in Group HR were under the age of 29 years, compared with 41% within Group ID. Further, a greater proportion of the latter were over 40 years of age (35%) while only 21% of Group HR were over 40. It would appear that the poor driving behaviors manifested by the high-risk drivers were closely tied to age and the habits of younger drivers. The lack of older Ss in Group HR could be accounted for by a number of variables; for example, social maturity and improved driving skills, movement into another category such as impaired drivers, and death.

If one assumes for the moment, that the problems of Ss in Group HR were largely cured by time and experience, it follows that the problems of the drivers in

Group ID were exacerbated by the same variable. Certainly, such a position would be congruent with prior conclusions that a high proportion of impaired drivers are alcoholic (14, 17), and, as their alcoholism develops, they present a greater degree of highway hazard.

Many of the responses of the impaired drivers to questions on the PIQ support such a description: for instance, the prevalence of suspected drinking problem and prior help for that problem, in addition to the quantities of alcohol they may have consumed and the frequency of that consumption. A substantial majority of the ID Ss reported that their families had objected to their drinking and about as many had experienced "blackout" as the result of excessive drinking. Few, if any, of the Ss in Group ID would have escaped being identified as alcoholic by virtue of their MAST score, but certainly a great proportion had some problem in control of alcohol consumption. It is, however, difficult (largely due to the ambivalent definition of alcoholism) to say what exact proportion of impaired drivers were alcoholic. In the opinion of the authors, treatment modalities and countermeasure programs which assume all impaired drivers to be alcoholic will be inappropriate for a large segment of the impaired driving population.

Groups AL and CA provided some of the most important demographic information. Despite repeated and vigorous attempts to obtain Ss for Group CA, the result was disappointing. After trying a number of sources (for example, rugby clubs and fraternal organizations) it became clear that persons who drink excessively do not volunteer to serve as control Ss in a study of alcohol-related social problems. The Ss were more readily obtained only after statements about their current drinking behaviors were eliminated from the recruitment message. Such defensiveness on the part of these Ss may have been due to their assumptions about the inaccuracy of the social sanctioning process or could have been based upon their private knowledge of their drinking and driving behaviors. Thus, information about the drinking behavior of the CA groups is not available. However, some insight might be provided by examining the characteristics of the Ss in Group AL.

Alcoholics under treatment have gone beyond the basic identifying criteria for alcoholism. It is interesting to note, however, that although the alcoholics in our sample had submitted themselves for treatment in a public institution, they were not unanimous in their acknowledgement of their alcoholism. Many continued to put up a defence against self disclosure of the nature of their situation. The most important characteristic of Group AL, however, was the low frequency with which Ss were located whose driving records were not affected by their alcoholism. In Alberta, at least, only a small proportion of the alcoholics under treatment have avoided the highway safety and law enforcement processes. Their driving citations present, therefore, the richest source of data to be used to identify the driver with alcohol-related problems. Obviously, the criteria for the identification of dangerous and potentially dangerous drivers requires further and intensive research.

This finding, however, supports the position that driving citation histories serve as a major variable in determining those who are to offer serious threats to highway safety (12). The data seem to imply that an individual convicted of impaired driving *may* have a drinking problem, and those with multiple alcohol-related offences may have exaggerated problems in alcohol-control. Further, the data imply that few alcoholic drivers would be missed by a screening procedure based on such information. It would be necessary, of course, to minimize the number of non-alcoholics erroneously selected for treatment by such criteria. This could be effectively accomplished, however, by programmed research of the selection and treatment processes. But, the information as to who the dangerous and alcohol-involved drivers are appears to be available in the Ss driving-citation history, as evidenced in Pollack's study (12).

Personality Characteristics of the Groups

In general, the results of the group comparisons on the selected personality scales were disappointing. Certainly, the Ss in Group AL presented a uniform and readily identifiable profile. It was, however, not a uniquely alcoholic profile, but rather a highly neurotic profile. The selected test scales showed no great ability to discriminate among the remaining groups of Ss. Moreover, the profiles of those groups appeared to be clinically 'normal'.

It would appear that the tests employed, and probably all general personality tests, are too gross to produce the necessary discriminations. While a specific test might be developed, it would be an arduous task requiring careful assessment and long-term validation. In addition, there is the question of the necessity of developing such an instrument. Individual drivers come to the attention of the courts and licensing agencies because of their driving behaviors. If these primary behavioral data could be made more predictive and their diagnostic ability improved, personality tests might become redundant. Pollack (12) has emphasized the predictive power of prior driving histories but further development and assessment is necessary. It is the authors' contention that this type of development would proceed more easily than that required for the development of an adequate personality test. However, personality tests might be employed to identify or confirm extreme cases of alcohol dependency or to identify the types of individuals best served by programs offering countermeasures to the drinking-driving problem.

APPENDIX A Test Materials

Howarth Personality Questionnaire (HPQ). The HPQ is a personality inventory consisting of 120 true-false questions (6). Prior analysis of the responses to these items have evidenced the existence of 10 polar factors which may be briefly described as:

1. *Sociability (Sy).* Measures the degree to which a person tends to seek out the company of others. This factor would be analogous to an introversion-extroversion dichotomy.

2. *Adjustment-Emotionality (AE).* An anxiety factor which includes a number of aspects of "neuroticism." Its main focus is on adjustment and emotional control.

3. *Ascendence-Dominance (AD).* The degree to which an individual is independent minded and assertive.

4. *Super Ego (SG).* Analogous to conscience in Freudian terminology. Measures responsibility, concern about moral standards and rules as well as other traits.

5. *Hypochondriac-Medical (HM).* An anxiety factor expressed in concern over bodily functions.

6. *Impulsiveness (IP).* Important aspect of extroversion. Degree to which individual acts on impulse rather than exercising control.

7. *Cooperativeness-Considerateness (CC).* Contains some aspects of tender mindedness and also of tolerance.

8. *Inferiority (IF).* Degree to which individual feels inferior to others.

9. *Persistence (PS).* Measure of persistence in one's work, activities and life goals.

10. *Trust versus Suspicion (TS).* Paranoia-like factor which has been replicated in normal Ss.

APPENDIX B

TABLE B1 *Variables Incorporated in Discriminant Function, in Order of Acceptance, Entering F Ratio, and Wilks Lambda.*

Step #	*Variable*	*F-ratio*	*Lambda*	*[^{F}approx. (df)]*
1	P.E.N.–N	54.62		
2	H.P.Q.–SG	17.73	.668	[35.26 (8,1262)]
3	H.P.Q.–IF	14.22	.613	[28.26 (12,1667.1)]
4	H.P.Q.–Sy	7.11	.586	[22.95 (16,1922.3)]
5	H.P.Q.–TS	8.84	.555	[20.24 (20,2083.8)]
6	H.P.Q.–AD	9.05	.525	[18.52 (24,2188.6)]

Cannonical Variates

Variables	1	2	3	4	5	6
N 1	–.194	–.006	–.123	.166	–.043	.127
SG 2	–.127	–.323	.071	.030	–.292	–.024
IF 3	–.214	.116	.247	–.380	–.038	–.078
Sy 4	.064	.175	.014	–.085	–.228	.128
TS 5	.160	.131	.018	.138	–.128	–.309
AD 6	–.092	–.105	–.253	–.233	.017	–.115
Constant	1.775	.569	.567	.898	4.812	1.139
Ergenvalues	.517	.184	.056	.003	0.0	0.0
Cumulative Proportion Variance	.679	.920	.996	1.00	1.00	1.00

REFERENCES

1. Button, A. D., A Rorschach Study of 67 Alcoholics. *Quarterly Journal of Studies on Alcohol*, 17, 35-52 (1956).

2. Cooley, W. W. and Lohnes, P. R. *Multivariate Data Analysis.* New York: John Wiley and Sons, 1971.

3. Crabb, D., Malfetti, J. L. and Stewart, E. I., *Development and Preliminary Tryout Procedure of Evaluative Measures for the Phoenix Driving While Intoxicated Re-Education Program.* Tempe: Arizona State University, 1971.

4. Finney, J. C., Smith, D. F., Skeeters, D. E. and Auvenshire, C. D., M.M.P.I. Alcoholism Scales, Factor Structure and Content Analysis. *Quarterly Journal of Studies on Alcohol*, 32, 1055-1060 (1971).

5. Hollingshead, A. B., *Two Factor Index of Social Position*. New Haven, Yale University Press, 1956.

6. Howarth, E., *Howarth Personality Questionnaire*. Edmonton: Department of Psychology, University of Alberta, 1973.

7. Lawlis, G. and Rubin, S., The Alcoholic Personality: A Research in Differential Personality Patterns. *Quarterly Journal of Studies on Alcohol*, 32, 318-327 (1971).

8. Little, J. W., Who is the Deadly Drinking Driver? *Journal of Criminal Law, Criminology and Police Science*, 59, 619-623 (1968).

9. Overall, J. E and Klett, J., *Applied Multivariate Statistics*. New York: McGraw-Hill, 1972.

10. Parkington, J. T. and Johnson, F. G., Personality Types among Alcoholics. *Quarterly Journal of Studies on Alcohol*, 30, 21-33 (1969).

11. Pinneau, S. R. and Melton, A., The Ecological Veracity of the Self-report. *Journal of Genetic Psychology*, 93, 249-276 (1958).

12. Pollack, S., *Drinking Driver and Traffic Safety: Final Report*. Los Angeles: University of Southern California, Public Systems Research Institute, 1973.

13. Selzer, M. L., Personality *vs* Intoxication as a Critical Factor in Accidents Caused by Alcoholic Drivers. *Journal of Nervous and Mental Disorders*, 4, 298-303 (1961).

14. Selzer, M. L., The Michigan Alcoholism Screening Test: The Quest for a New Diagnostic Instrument. *American Journal of Psychiatry*, 127, 1971.

15. Selzer, M. L., Payne, C. E., Quinn, J. and Westervelt, F. H., A Depression Aggression Syndrome Related to Accidents Caused by Alcoholics. *Proceedings of the 4th International Conference on Alcoholism and Traffic Safety*, 297-303 (1966).

16. Schmidt, W. S., and Smart, R. G. Alcoholics, Drinking and Traffic Accidents. *Quarterly Journal of Studies on Alcohol*, 20, 631-644 (1959).

17. Waller, J. A., Chronic Medical Conditions and Traffic Safety: Review of the California Experience. *New England Journal of Medicine*, 273, 1413-1420 (1965).

18. Waller, J. A., Patterns of Traffic Accidents and Violations Related to Drinking and Some to Medical Conditions. *Quarterly Journal of Studies on Alcohol*, Supplement #4, 118-137 (1968).

19. Zelhart, P. F., Types of Alcoholics and their Relationship to Traffic Violations. *Quarterly Journal of Studies on Alcohol*, 33, 811-813 (1972).

20. Zelhart, P. F., *The Alberta Impaired Drivers Program: Final report, Phase I*. Edmonton: Department of Psychology, University of Alberta, 1973.

The Vermont Driver Profile: A Psychometric Approach to Early Identification of Potential High-Risk Drinking Drivers

M. W. Perrine[1,2]

It is said that "a man drives as he lives." To the extent that this assumption is correct, it would be very useful to obtain information concerning relevant biographical and psychological characteristics of potential high-risk drinking drivers *before* they become involved in serious problems on the highway. Important questions are: what information is relevant, and how and when should it be obtained? The present paper is primarily addressed to the first question, but the other two questions are briefly examined since they relate to the pragmatic and feasibility aspects of the problem. The most important single factor underlying the present approach is the well-established role of alcohol in driving problems.

BACKGROUND

Regardless of whether it is ultimately judged to be a basic right or just a privilege, the driver's license has long been considered the most feasible administrative means of recognizing an individual as one who is sufficiently qualified – at least at the time of testing – to participate in the highway transportation system. Official policy typically assumes the validity of driver licensing procedures and initially treats all those who pass as being equal. Unfortunately, highway safety experience has demonstrated that all those who possess the driver's license are clearly *not* equal in terms of crash involvement. That is, some drivers are frequently involved in crashes and others are only occasionally involved, whereas many drivers are never involved in a crash. Thus, it is generally agreed that identification of crash-involved drivers before the fact would be ideal, even though extremely difficult. Previous attempts at achieving this ideal have not met with appreciable success, primarily because of the necessity to avoid the appearance of possible official discrimination against any single individual through use of decision criteria which are based upon anything other than perfect validity.

---

[1] Project ABETS: Laboratory for Alcohol and Drug Studies, Department of Psychology, University of Vermont, Burlington, Vermont, U.S.A.

[2] This study was conducted by the Psychological Research Foundation of Vermont under the terms of a subcontract with the Vermont Department of Mental Health as a scheduled program element of the Vermont Alcohol Safety Action Project ("Project CRASH") which is supported by Contract No. FH-11-7543 with the National Highway Traffic Safety Administration of the U.S. Department of Transportation. The interim report on this program element is cited in the references of the present paper (25). The opinions, findings, and conclusions expressed in this report are those of the writer and not necessarily those of any of the above organizations.

A recent approach which is more promising involves the assumption that it is both possible and feasible at the time of the driver licensing examination to detect probable high-risk drinking drivers, that is, those who have an elevated probability of being involved in a fatal or serious injury alcohol crash, or of being convicted of drunken driving (driving while intoxicated (DWI)). However, the full utility of this approach should perhaps first be demonstrated at a quasi-official level. For example, the identified individuals could be advised that they are at probable high risk; then it could be strongly recommended that they avail themselves of additional training, counseling, rehabilitation, or whatever is appropriate in the particular case.

The Driver Profile Countermeasure[3] of the Vermont Alcohol Safety Action Program ("Project CRASH") was originally designed to test the utility of this approach, but unilateral program modifications subsequently reduced the effective scope of such a projected test. Thus, the present study represents the best partial test that was still possible within the managerial constraints of those program modifications.

Issues

An overview of the more fundamental issues involved in the concept of driver selection-prediction has been concisely stated by Reese (30):

> *As is well known, the highway transportation system consists of three components: the driver, the vehicle, and the road. To provide safe and efficient highway transport, government has imposed safety measures that relate to each. The function of the safety measures relevant to the driver is to prevent the sort of human failure that results in highway deaths, injuries, and property damage. The desire of government to prevent such human failure is expressed in the driver licensing programs of the states. Since the goal of licensing is prevention of accidents, the licensing programs must be designed to predict the sort of human failure that results in accidents. Government has decreed that persons who may be predicted to fail as drivers should be denied admission to the driving society and that those members of the driving*

Preparation of the original interim report (25) was greatly facilitated by the technical assistance and personal diligence of Mrs. Mary Anne Freedman, to whom the writer is especially grateful for the necessary programming and data processing. In addition, specific statistical analyses were conducted and/or interpreted by several consultants: Dr. Lawrence R. Gordon (factor analyses), Dr. David C. Howell (discriminant analyses), and Dr. David G. Whitmore (multiple regression analyses).

The Driver Profile countermeasure of the Vermont Alcohol Safety Action Program has needed and has received the full support and active cooperation of a number of individuals. We are especially indebted to Commissioner James E. Malloy of the Vermont Department of Motor Vehicles, as well as to key members of his staff: Mr. Ugo J. Sartorelli, Miss Laura E. Parker, Mr. Donald C. Dolliver, and Mr. Ernest D. Matthews.

We also wish to express our special appreciation to those individuals in NHTSA's Office of Alcohol Countermeasures who were so helpful, not only during the initial development of this program element, but throughout the period of its gradual refinement and implementation: Dr. Robert B. Voas, Mr. Hershell Hawley, and Mr. Jerome Holiber, as well as to the contract technical managers of the Vermont Alcohol Safety Action Program: Mr. Marvin H. Wagner and Mr. Charles Keiper. Two members of the Project CRASH staff were particularly helpful: Mrs. Judy Gitchell and Mrs. Linda Flowers. Finally, we wish to express our gratitude to Dr. Barbara Cheng, Mrs. Elizabeth J. S. Cowan, Mrs. Marian Bickford, Mrs. Candice McBeath, and Miss Robin Adair for their assistance.

[3] The only accurate detailing of this countermeasure as originally designed is presented in The Operational Plan for the Driver Profile (revision of February 1972) and in the paper entitled, *"The Driver Profile:* Using driver licensing as a countermeasure for highway crashes involving alcohol" (23), both of which are reprinted in the full report of the present study (25).

> *society who may be predicted to fail should be removed from the society.*
>
> *Therefore, the primary function of the driver licensing may be stated simply. Its task is to identify the applicants and licensees who will fail and either deny them admission or expel them. But to do so depends on the validity of the major premise on which driver licensing is founded. The premise is that those persons who will later become involved in accidents are identifiable. Accordingly, a corollary function of driver licensing policy is to provide the identification criteria and standards of judgment that constitute the substance of driver selection-prediction systems. However, is it realistic to assume the validity of the major premise? Are persons who will fail as drivers identifiable? May identification criteria be constructed?* (p. 35)

Since the inception of driver examination programs, the most fundamental problem continues to be that of evaluation. The basic question for evaluation concerns the utility of driver licensing examinations as a means to the end of identifying driver applicants who would most likely have crashes if allowed to participate in the driving society. However, it is difficult to evaluate these programs and to establish the validity of the specific procedures for at least three major reasons: (a) those who fail the licensing tests are not allowed to drive and therefore do not have an opportunity to produce data for evaluative purposes; (b) accident repeaters comprise but a small percentage of the driving population and are therefore difficult to study (3, 4); and (c) the fatal crash, which usually serves as the ultimate criterion measure, is a statistically rare event and therefore very difficult to study scientifically (24).

Considering the fatal crash (or even the citation conviction) as the ultimate criterion measure means not only using a rare event, but also one which occurs only *after* the applicant has been tested and licensed. Accordingly, it is impossible to obtain these measures in time to evaluate the effectiveness of a particular licensing test for a particular applicant. Thus, all atempts at evaluation tend to be "after-the-fact" studies. Therefore, it is necessary to obtain *intermediate measures* which have at least a correlational association with the ultimate criterion measure.

Implicit intermediate measures have traditionally been obtained from performance on the driver licensing written examination, the road test, and the eye test. However, since these assorted tests have not been completely adequate to the task of identifying the high-risk driver, some other intermediate measures are needed. Possible measures are: performance on a driving range, in a driver education program, and on a driving simulator, and responses on predictor variables (such as would be administered in the form of a questionnaire or interview). The present study is based upon this latter set of intermediate measures.

The present approach seeks significant relations between the responses on those probable predictor variables and selected validation criteria that were already available at the time of testing (e.g., the previous driving record of experienced out-of-state drivers applying for a Vermont license). The scheduled follow-up study was designed to include the actual driving record accumulated by the present respondents during the intervening one-year period as an additional validation criterion, but this study fell victim to a unilateral management decision.

Rationale

The rationale for enlisting psychometric methods in the task of improving and evaluating driver licensing programs is based upon the assumption that individuals who subsequently become labeled as 'bad' or high-risk drivers in terms of the ultimate criterion variables of crashes and citations differ systematically on some combination of biographical, attitudinal, and personality variables which can be measured before the fact. In other words, it is assumed that there are systematic differences between these high-risk drivers and those other drivers who can be defined as low risk in terms of a subsequent crash- and citation-free driving record. Furthermore, it is assumed that this information could be obtained when the individual submits himself as an applicant for a driving license. Although this psychometric approach has great appeal because of its obvious administrative feasibility and potential cost effectiveness, its utility must in turn be evaluated on the basis of the validity of underlying assumptions.

A number of personal variables that are significantly correlated with the ultimate criterion measures of crashes and citations have already been identified and are discussed below. However, less success has been reported in the limited number of efforts to determine the relation of such personal variables to the intermediate measures typically used in driver licensing programs. Therefore, the original scope of the present project had specified the follow-up analysis of accumulated driving records for validation purposes. However, this must now be left for some future study.

Personal Variables, Crashes, and Alcohol

Although a number of psychometric and epidemiologic studies have been conducted over the years in attempts to uncover personal characteristics (such as "accident proneness") which are linked with crash involvement, the present discussion is limited to those studies in which alcohol was a primary variable. These studies fall roughly into three general categories which differ in their respective methodological advantages and disadvantages: (a) analysis of official record files (police and/or motor vehicle department), (b) roadside research surveys (both case/control and non-case control studies), and (c) personal interview and/or testing of specifically identified target groups (e.g., convicted DWIs, hospitalized alcoholics, crash-involved drivers in "driver rehabilitation classes", and even the next-of-kin of fatally injured drivers). Space limitations do not permit extensive consideration of these studies; however, they have recently been reviewed by Perrine (26, 27). Therefore, only the most salient aspects and consistent findings are noted below, along with references to relevant studies.

The personal variables most frequently studied are those which are relatively obvious and/or relatively straightforward and easy to obtain either from official records or from brief interviews. For the same reasons, these variables tend to have the highest potential utility for subsequent administrative and/or countermeasure purposes. The relevant variables tend to fall into three general classes, the first of which is essentially demographic and the second two of which are essentially behavioral: (a) *biographical background variables* (sex, age, etc.), (b) *driving variables* (driving history, record, and drinking-and-driving patterns), and (c) *drinking variables* (in particular, patterns of alcohol use in terms of quantity, frequency, and variability of consumption). Each class is considered below separately, but in terms of each of the other two classes.

Biographical variables. A number of studies have found significant relationships between crashes, alcohol, and the following biographical variables: sex, age, marital status, and occupational level. Less consistent, but still potentially useful findings have been reported for such single and combined variables as race, ethnicity, religious affiliation, educational level, socioeconomic status, social stability/instability, social mobility, leisure activities, and contact with social agencies (1, 2, 5-12, 15, 16, 17, 19, 20, 22, 24, 29, 32-36). The principal findings concerning each of these primary moderator variables are considered below in conjunction with one or two representative studies in each case.

Regarding *sex*, drinking-and-driving problems are clearly a predominantly male domain. In fact, by contrast to approximately equal representation in the adult population, males comprise a larger proportion of: licensed drivers (about two-thirds), drivers sampled during roadside surveys (about 80%), fatally injured drivers (about 90%), as well as virtually all convicted DWIs (about 98%) (8, 9, 29).

Regarding *age*, the general finding is that younger drinking drivers who get into trouble on the highways do so at lower average blood alcohol concentrations (BACs) than do their middle-aged or older counterparts (29). However, two important additional factors must also be considered, namely, crash involvement and exposure. On the basis of his extensive review of the interrelations between age, alcohol, and crash involvement, Zylman (36) summarized the data from a number of studies showing that alcohol increases the probability of crash involvement among teenagers much more than among drivers aged 20 to 24, who are in turn at higher risk than those in the range from 25 to 69, whereas the probability of crash involvement again rises among drivers aged 70 or older. In his definitive study of the interrelations of age, exposure, and alcohol involvement in nocturnal crashes, Carlson (6) developed a new method for assessing exposure which allows for a more accurate determination of the contribution of the other two factors. Regarding the reasons for the high crash involvement of drivers in the 16 to 25 age group, Carlson (6) concluded that these young drivers face two learning situations: first, learning to drive – with peak fatal crash involvement at age 18, and second, learning to drive after drinking – with peak alcohol-involved fatal crashes at age 21. These two learning situations result in crash involvement which is larger than can be attributed to exposure. Nevertheless, young drivers continue to have a disproportionately large number of crashes even after these two peaks in the learning period. Carlson concluded that the high crash involvement of drivers 16 to 25 corresponds to a high degree of night driving which he feels is the most significant single modifier variable after BAC itself. Thus, the apparent over-representation of youth in the subpopulation of fatally injured drivers – both with and without alcohol – is partially attributable to their lifestyle which involves night driving for recreational purposes.

Regarding *marital status*, married drivers are found to be under-involved in drinking-and-driving problems relative to unmarried drivers (single, divorced, separated, or widowed) when drivers under age 25 are excluded from analysis. Divorced and separated male drivers are especially over-involved in drinking-and-driving problems, as well as in alcohol usage in the nocturnal driving population (5, 10, 15, 16, 29, 35).

Regarding *occupational level*, several studies have found that drivers from the lower levels are over-represented among those who have drinking-and-driving problems, especially DWI convictions. This pattern becomes even more pronounced when younger drivers (under age 25) are excluded from analysis.

Driving variables. A number of studies have found significant relations between alcohol, selected biographical variables, and the following driving variables: previous crashes, citations, suspensions, experience, and exposure (6, 8, 12, 29, 35). Regarding previous *crashes*, several investigators found that drivers with alcohol-related problems (alcoholics, DWIs, and fatally injured drivers with high BACs) have a higher incidence of crashes than random samples of the driving population (8, 12, 29). In the most comprehensive of these studies, Clark (8) reported that the DWI sample had the worst crash experience, with two-thirds of the sample having one or more crashes and with the average number of crashes being nearly three times higher than the average among a random sample of licensed drivers. She concluded that the group which misuses alcohol in the driving situation and is convicted of DWI is also a high-risk crash group prior to the incident which led to the conviction.

Regarding *driving convictions*, several studies have indicated their utility as a more sensitive measure of deviancy than crashes (8, 12, 29). In both the Michigan (8) and the Vermont (29) studies, the DWIs had significantly more previous driving convictions (excluding the one for which they were sampled) than the two approximations of the driving populations obtained respectively by a sample of licensed Michigan drivers and by a sample of case/control drivers interviewed on Vermont highways. More specifically, the Michigan DWIs had four times as many convictions and the Vermont DWIs had seven times as many convictions as the random samples of drivers. In fact, the Michigan DWIs averaged almost one conviction per year.

Driver fatalities in both studies (8, 29) also had more convictions for moving violations than the two random samples of drivers, but fewer than the DWI samples. Nevertheless, the driver fatalities with high BACs in Michigan were more similar to the DWIs in number of previous convictions, whereas those driver fatalities with no alcohol were more similar to the random sample of licensed drivers.

Regarding *license suspensions*, results similar to those for driving convictions discussed above were obtained in the Vermont study (29). For example, 14% of the case/control drivers had suffered one or more suspensions (during all years of driving), whereas 60% of DWIs had already experienced one or more suspensions prior to the suspension in force at the time they were sampled. Perhaps even more remarkable, 44% of these DWIs had already experienced two or more previous suspensions. Hence, it can only be concluded that the overwhelming majority of individuals convicted for DWI were already well known to the courts and the motor vehicle officials.

In conclusion, these investigations of driving variables generally tend to support the popular assumption that past driving behavior is the best *single* predictor of future driving behavior. However, a major question which awaits further investigation concerns the extent to which this assumption holds within individual, as opposed to within group or subpopulation. In other words, with an event as relatively rare as a crash, to what extent can predictions be made which are specific to a given individual, as opposed to predictions which are based upon group membership?

Drinking variables. Perhaps because of the relatively sensitive and stigmatized nature of the topic, very few studies are available in which data concerning drinking patterns were obtained from drivers, especially in conjunction with BAC data. The extent of the drinking pattern information obtained in previous studies ranges from quick and simple questions about drinking only on the day of the survey (whether or not; if yes, where and when) (e.g. 5, 9) to studies in which questions were asked about potentially very sensitive alcohol topics (such as, frequency of 'getting high' and of exceeding one's capacity, driving after drinking, having alcohol problems, hangovers, and blackouts) (2) and in which very detailed questions were also asked about frequency and quantity of usual consumption of the major alcoholic beverage types as well as typical occasions and places of drinking (21, 29). Reviews and subsequent analyses of some of these studies have been presented by Cosper and Mozersky (10), Hurst (14), and Perrine (24).

The Vermont study (29) has been selected for the purposes of the present discussion, not only because it provided the immediate background for the present study, but also because it contains the most extensive alcohol data for the widest range of the driving spectrum. Furthermore, the Vermont study has the unique advantage of being able to validate aspects of reported drinking patterns by comparing them with actual BACs in samples of driver fatalities, control drivers, and "clear-record" control drivers, as well as DWIs.

A drinking classification system was developed in the Vermont study which gave expectancy figures for a driver's reaching the impaired level of alcohol consumption (29). The system was based on reported frequency of consumption together with quantity of alcohol consumption at a sitting. The resultant Quantity-Frequency Index (QFI) for preferred beverage is based upon that beverage which was reportedly consumed most frequently and in largest quantity, regardless of whether it was beer, liquor, or wine. Regarding the fatally injured drivers, these data were obtained in interviews with next-of-kin. The QFI data were compared and cross-tabulated with selected biographical variables and driving variables, as well as with obtained BACs. An overview of the reported drinking patterns is presented in Figure I (adapted from 29, Figure 6-7), in which the proportions of roadblock control, clear-record, DWI, and deceased drivers are plotted as a function of a modified four-category (light, light-medium, medium, or heavy) QFI for preferred beverage. From this figure, it is clear that as a group, the DWIs are decidedly different in their self-reported drinking patterns from the other three samples, each taken as a group.

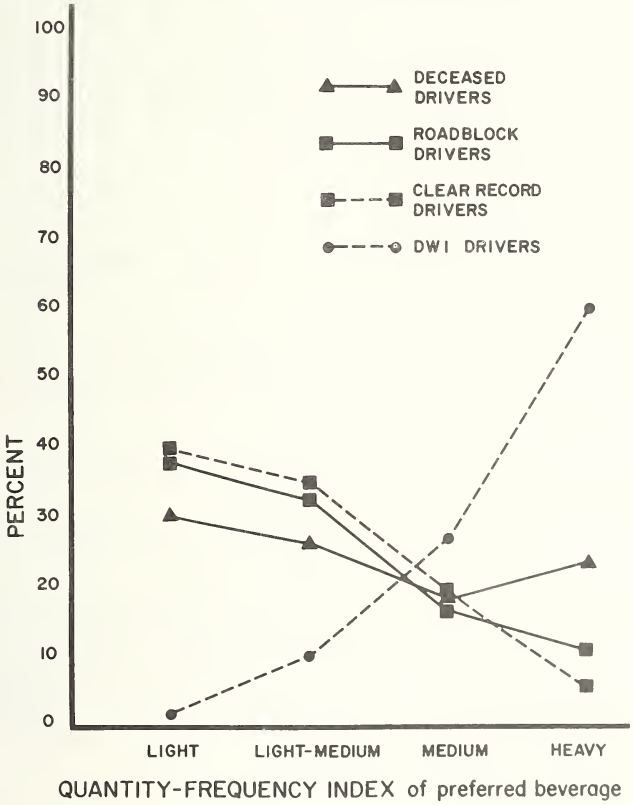


Figure 1 *Proportion of roadblock, clear-record, DWI, and deceased drivers with light, light-medium, medium, or heavy Quantity-Frequency Index for preferred beverage.*

One particularly noteworthy finding concerning type of beverage was reported in the Vermont study (29). Frequent and excessive use of beer was highly correlated with BACs of 100 mg/100 ml or higher. More specifically, relative to fatally injured drivers with no alcohol, over twice as many with high BACs were reported to have drunk beer daily; and relative to control drivers with no alcohol, almost twice as many with high BACs reported that they drank beer daily. Among those who reportedly drank beer, 67% of DWIs and 80% of fatalities with high BACs were reported to have drunk it daily. The investigators (29) offered several recommendations on the basis of having found that heavy beer drinkers were over-represented among crash and citation problem drinkers who had been involved in crashes and driving convictions.

Perrine *et al.* (29) concluded from the analyses of the alcohol consumption data that these QFI variables are in fact useful in differentiating across the spectrum of drivers. Further encouragement for the utility of these variables was felt to be provided by the relation of the *reported* alcohol consumption data (QFI) to the *actual* consumption data (BACs) and to the driving variables (both self-reported and official record-check information).

Even further evidence of this utility resulted from a discriminant analysis of 12 selected variables (29). The four variables which were significant in discriminating between the clear-record drivers and the DWI drivers were, in order of importance: (a) the number of convictions for driving violations, (b) occupational level, (c) frequency of beer consumption, and (d) quantity of liquor consumption. On the basis of a discriminant function using these four variables, 95% of the clear-record drivers and 87% of the DWIs could have been correctly classified. Thus, it was possible to determine classification 'hits' and 'misses' on the basis of a weighted function which incorporated components from an individual's driving record, from his socio-economic status, and from his reported patterns of alcohol use.

Objectives and Specific Aims

The overall objectives of this Driver Profile countermeasure were originally expressed as follows:

1. To develop a more effective examination system for driver licensing.

2. To evaluate the effectiveness of the revised and expanded examination system in terms of its predictive efficiency.

3. In particular, to develop a specific questionnaire for identifying the problem-drinking driver on the basis of psychological-biographical variables.

4. To evaluate the effectiveness of the Driver Profile as a screening and diagnostic instrument for identifying probable high-risk drivers for specific referral to instruction, counseling, or therapy.

The specific aims of the present study focused on developing the Driver Profile questionnaire further, in an effort to enable accurate early identification of potential high-risk drinking drivers. More specifically, the present study was intended to aid in locating and removing useless variables and items in order to improve the efficiency of the Driver Profile questionnaire. In addition, a preliminary assessment of the validity of this Driver Profile approach was attempted.

METHOD

The Driver Profile questionnaire was subdivided into two separate parts for administrative purposes (namely, the Biographical Data Schedule, and the Abridged Driver Profile) which in combination obtained data from subsets of the following classes of variables: biographical, driving history, drinking history, and attitudes. In conjunction with the Vermont Department of Motor Vehicles, two samples of applicants for a driving license were selected for special testing in addition to the official licensing examination. The first sample also received both parts of the Driver Profile questionnaire, whereas the second sample only received the relatively brief Biographical Data Schedule, but not the longer Abridged Driver Profile.

Respondents

The respondents in the present study were labelled according to their reasons for taking the Department of Motor Vehicles, (DMV) examination, namely: Learners, Operators, DWI, Fleet Safety, and Reexaminees and Special Examinees. The distributions in frequency and per cent of all respondents are presented in Table I, arranged by category or reason for taking the DMV examination, sex, and the outcome of the DMV examination, according to Driver Profile status. The criteria for admission to each of these categories are as follows:

Learners. Applicants for a learner's permit must be at least 15 years of age, and are required to pass the DMV written examination, but are not expected to be able to pass the DMV road test. If successful in passing the written examination, they are issued a one-year Learner's Permit which is renewable. Typically, these applicants have no previous driving experience on public roads, and are applying for the learner's permit in order to matriculate in a driver education course, completion of which is required of applicants for a junior operator's license.

Juniors. Applicants for a junior operator's license must be 16 or 17 years of age, must obtain parental permission, must have successfully completed a driver education course, and must pass both the written and the road tests. Only a few such applicants were obtained in the present samples and their data were grouped with that from the operators.

Operators. Applicants for an operator's license must be at least 18 years of age, and must pass both the written and road test, although the latter is usually waived for out-of-state applicants who already have driving experience.

Fleet safety. Applicants consist exclusively of Vermont State employees who already possess a valid operator's license, but must nevertheless be tested as part of the State of Vermont's Fleet Safety Program in order to operate a State vehicle or to drive their own vehicle on State business.

DWI. These drivers are individuals who were convicted of a "driving-while-intoxicated" violation and were required to complete the full DMV examination series as part of the new reinstatement procedure.

Re-examinees and special re-examinees. These are individuals required by the Commissioner of Motor Vehicles to take the full examination series. However, since only nine such cases were obtained, this category of applicants was not analyzed in the present study.

The obtained samples. During the period from November 1, 1971 through August 23, 1972, 840 applicants received the Driver Profile. Of these, 254 were Learners, 381 Operators (which included 2 Junior Operators), 99 Fleet Safety, 82 DWIs, 9 Re-examinees and Specials, and 15 Unknowns (respondents with inadequate information for identification purposes).

TABLE I *Distribution in Frequency and Per Cent of all Respondents Arranged by Respondent Type, Sex, and Outcome of DMV Examination According to Driver Profile Status*

Respondent Type, Sex and Outcome of DMV Examination		Driver Profile		Non-Driver Profile	
		N	%	N	%
Learner					
Male					
Pass		25	21	123	44
Fail		92	78	159	56
	Subtotal	117	(46)	282	(46)
Female					
Pass		39	28	153	46
Fail		98	72	177	54
	Subtotal	137	(54)	330	(54)
	TOTAL	254		612	
Operator					
Male					
Pass		185	74	274	78
Fail		64	26	77	22
	Subtotal	249	(65)	351	(57)
Female					
Pass		80	61	196	74
Fail		52	39	68	26
	Subtotal	132	(35)	264	(43)
	TOTAL	381		615	
Fleet Safety					
Male					
Pass		67	85	–	–
Fail		11	14	–	–
Unknown		1	1	–	–
	Subtotal	79	(80)		
Female					
Pass		19	95	–	–
Fail		1	5	–	–
	Subtotal	20	(20)		
	TOTAL	99			
DWI					
Male					
Pass		47	60	–	–
Fail		20	26	–	–
Unknown		11	14	–	–
	Subtotal	78	(95)		
Female					
Pass		–	–		
Fail		–	–		
Unknown		4	5		
	Subtotal	4	5		
	TOTAL	82	(100)		
Re-examinee					
	TOTAL	9			
Unknown					
	TOTAL	15		54	
GRAND TOTAL		840		1283	

For comparison purposes, a control sample of 1,283 applicants completed only the Biographical Data Schedule and were labeled Non-Driver Profile. Of these, 612 were Learners, 615 Operators (which includes 3 Juniors), and 54 Unknowns. Further details concerning the sampling are presented in Table I.

Test Instruments

Driver licensing examination. The Vermont Department of Motor Vehicles developed a common pool of approximately 80 multiple-choice questions from which several parallel, 20-item forms of the official written examination for driver licensing were constructed. An applicant must answer at least 16 of these 20 questions correctly in order to pass the DMV written examination.

Biographical data schedule. This part of the Driver Profile questionnaire obtained information on the following variables: sex, age, educational level of applicant and of each of his parents, student status, employment status, occupational level, number of jobs in previous 5 years, community type, marital status, number of previous marriages, amount of driving experience, driver education status, and estimated annual mileage. The code categories used in the analyses of these variables are presented in Table II. The Biographical Data Schedule was administered to all respondents from both samples in paper-and-pencil form (a copy of which is presented in (25)).

The abridged driver profile. This second questionnaire used in the present study represents only a portion of the Driver Profile instrument originally specified and developed (25). That the abridged version of the Driver Profile exists and was used in its present form was due to: (a) certain unilateral managerial decisions, and (b) the necessity to reduce the length of the questionnaire to fit within the limitations of the specially re-designed ITEM apparatus (see (25) Appendix C, pp. 3-4) which Gemco modified for this application.[4]

The ITEM is a semi-automated test machine. This apparatus was originally scheduled for use with both the DMV driver licensing examination and the Abridged Driver Profile (see (25), Appendix C, pp. 3-4). However, this equipment was used only sporadically due to the many mechanical, electrical, and logistical problems which emerged.

The Abridged Driver Profile questionnaire (see (25) Appendix E) obtains information on the following variables: *driving history* (in terms of experience, exposure, previous crashes, suspensions, violations, etc.); *drinking history* (in terms of frequency and quantity of alcohol consumption, of preferred alcoholic beverage, of crashes after drinking, etc.) and social *stability-instability* (number of marital partners, number of jobs, etc.) (Table II). Information concerning the social background variables was provided on the Biographical Data Schedule described above.

The more psychological portion of the Abridged Driver Profile includes questions about drinking-and-driving attitudes and knowledge, as well as selected personality and attitudinal items from the Vermont Error-Choice Test of Driving Skills (25) and the Driver Attitude Survey (DAS) (31). As used in the present study, the DAS consisted of 115 items, each of which has three response options (yes; ?; no). The

---

[4] The total number of questions in the Abridged Driver Profile was limited by the slide capacity of the Kodak carousel magazines used in the ITEM. Furthermore, the maximum number of response options allowable for any multiple-choice questions was only four, due to Gemco's inability to re-engineer the response options on the console and the hard-wired logic within the limitation of our budget and time schedule.

TABLE II *Selected Variables and Their Code Categories Used in the Analysis*

VARIABLE	CODE CATEGORIES
Biographical Items	
Sex	male; female
Age	(a) <20; 20-24; 25-39; 40+ (b) <25; 25-39; 40+ (c) <25; 25+
Educational level	high school or less; some college or more
Father's educational level	
Mother's educational level	
Marital status	single; married; other (widow, div., sep.)
Number of marriages	one; two or more
Student status	student; non-student
Employment status	full-time; part-time; unemployed
Number of jobs in the last 5 years	one; two; three or more
Community type	farm, village, or small town (<5,000) city (5,000+)
Driving history	
Outcome of DMV (written) examination	pass (16+ correct); fail (<16 correct)
Years of driving experience	<6 months, 6 months-5 years; 5 or more yrs
Driver education training	yes; no
Annual mileage	<2,499; 2,500-9,999; 10,000-14,999; 15,000 or more
Number of crashes in the last 3 years	(a) none; one; two or more (b) none; one or more
Number of MV convictions in the last 3 years	
Number of license suspensions	
Crashes after drinking	yes; no
Drinking patterns	
Beer consumption quantity	(a) none; 1-2; 3-4; 5 or more (b) none; 1-2; 3 or more
Wine consumption quantity	
Liquor consumption quantity	
Consumption quantity of preferred alcoholic beverage	(a) 1-2; 3-4; 5 or more (b) 1-2; 3 or more
Attitudes	
Accident attitude score	0-10; 11 or more
Violation attitude score	0-9; 10 or more
Alcohol attitude score	0-2; 3 or more
Error Choices:	
Q.116: People who take risks on the highway	Conservative (are unaware of the dangers); Liberal (are in the majority)
Q.117: The use of seatbelts reduces the chance of fatal injury in traffic accidents by	Conservative (50%-70%); Liberal (10%-30%)
Q.118: The average man can safely drive a car after_____ alcoholic drinks	Conservative (0-3); Liberal (6-9)
Q.119: Most accidents are due to excessive	Conservative (speed); Liberal (drinking)
Q.120: First offence DWI violators should lose their license for____ months	Conservative (18-36); Liberal (2-6)
Q.121: Approximately____percent of fatal automobile accidents involve alcohol	Conservative (60-80); Liberal (20-40)
Q.122: In Vermont the legal DWI limit should be at the BAC of____________	Conservative (0.5-.08); Liberal (.12-.15)

items concern: attitudes toward selected driving behaviors, situations, and emergency reactions, as well as toward alcohol; personal driving behavior and exposure; personality characteristics; basic intelligence; and consistency in responding. These items are scored on 7 scales, but only the following 3 were at all useful:

A (accident attitude) scale: a high score indicates a tendency toward accident "proneness."

V (violation attitude) scale: a high score indicates a tendency toward violation "proneness."

AL (alcohol attitude) scale: a high score indicates a favorable attitude toward alcohol use and *may* indicate a tendency toward alcoholism.

Seven attitudinal items were selected from the Vermont Error-Choice Test of Driving Skills (VECTDS), which was devised at Project ABETS in an attempt to obtain a structured but indirect (or 'disguised') measure of an individual's attitude toward driving topics without his being aware that his attitudes were under investigation (25). These seven multiple-choice questions have either two or four response options, none of which is correct. Since the correct answer is not provided, the respondent must select a response which is erroneous. The systematic error in one direction of another in checking alternatives is taken as the measure of the individual's attitude on the particular topic. For example, the VECTDS is concerned with highway safety and driving behavior; and accordingly, the direction of error-choices is considered to reflect driving-related attitudes which are characterized as "risky" (or "liberal") on the one side, and as "cautious" (or "conservative") on the other side. A partial indication of the content and scoring of these seven error-choice items is provided at the bottom of Table II.

Although the Abridged Driver Profile had been specially re-designed and formated for mechanized presentation on the ITEMS, it was actually administered in paper-and-pencil form (a copy of which is presented in (25) Appendix E).

Sampling Procedures

The sampling criteria had been given to Project CRASH (The Vermont ASAP) for implementation. Project CRASH unfortunately modified the sample sizes, criteria, and schedule before providing DMV personnel with the instructions for obtaining respondents.

The DMV inspectors and examining station personnel received a short preliminary briefing by one of the Project CRASH staff members. In accordance with the modified schedule of criteria provided by Project CRASH, the DMV personnel decided: (a) which particular applicant was to be asked to complete the Biographical Data Schedule and which applicants were not; as well as (b) which particular applicant was to be asked to complete the Abridged Driver Profile questionnaire and which applicants were to be exempt from taking it. Thus, the DMV personnel were making decisions on selecting a given individual, but were doing so within the guidelines supplied by Project CRASH.

The data were obtained through the cooperation of DMV personnel at official examining stations throughout the four-county ASAP study area. A limited amount of data was also obtained by using the Project CRASH motorized van, but persistent mechanical and electrical problems with the ITEM apparatus and with the van itself prevented this mobile testing system from being used in the capacity originally planned. Once obtained, the data were assembled and reduced by Project CRASH personnel in preparation for delivery (on tape) to the Psychological Research Foundation of Vermont for analysis and interpretation.

RESULTS

The respondents were separated for analysis on the basis of 4 major sorting variables, and are referred to throughout the rest of the present paper by these labels: *Driver Profile status* (whether or not the respondent was selected to receive the Driver Profile questionnaire, and thus referred to as either Driver Profile or Non-Driver Profile), *reason for taking the DMV examination* (the category of applicant, specified as: Learner, Operator, Fleet, or DWI), *outcome of DMV examination* (whether or not the respondent passed or failed the DMV 'written' driver licensing examination, and specified as Pass or Fail), and *sex*. However, the present report is limited to those subsets of respondents for which the most meaningful comparisons and analyses can be made, namely, adult males who had completed the Driver Profile questionnaire and were in the following categories: Operator/Pass, Operator/Fail, Fleet (all), or DWI (all). Thus, all females, all learners, and all Non-Driver Profile respondents were excluded from the analyses reported below. Furthermore, due to space limitations, only the 4 most important sets of analyses have been selected for presentation: (a) between-group comparisons of DWIs with all other groups, (b) factor analyses, (c) discriminant analyses, and (d) multiple regressions.

DWIs Versus All Other Groups

The purposes of these comparisons were: (a) to obtain a preliminary indication of the validity of the present psychometric approach by examining results from a 'known group' (consisting of individuals who were already in trouble because of driving after drinking), and thereby (b) to provide a basis for preliminary evaluation of the potential validity indicators. Accordingly, the male DWIs were compared with the male Operators who passed, the male Operators who failed, – and the male Fleets. The results of these comparisons can be summarized at the most general level by saying that, as a group, the DWIs differed from the other three groups on almost every variable which was analyzed. In the following summary of these comparisons, the specific variables and the direction of differences are mentioned for every Chi-square analysis that produced either a significant difference ($p < .05$) or a strong trend which approached significance.

TABLE III *Adult Male Respondents Arranged by Age According to Reason for Examination and Outcome*

	Operators				Fleet		DWI	
	Pass		Fail					
Age	N	%	N	%	N	%	N	%
<20	11	6	8	12	7	9	–	–
20 - 24	55	30	24	38	26	33	12	15
25 - 39	81	44	20	31	29	37	35	45
40+	36	20	12	19	17	22	31	40
Unknown	(2)	–	(0)	–	(0)	–	(0)	–
TOTAL	185	100	64	100	79	101	78	100

TABLE IV *Adult Male Respondents Arranged by Driving Variables According to Reason for Examination and Outcome*

Driving Variables	Operators				Fleet		DWI	
	Pass		Fail					
	N	%	N	%	N	%	N	%
Number of crashes in the last 3 yrs.								
None	118	72	32	74	59	81	28	42
One	36	22	9	21	8	11	26	39
Two or more	11	7	2	5	6	8	13	19
Not applicable	(8)	–	(11)	–	(2)	–	(2)	–
Unknown	(12)	–	(10)	–	(4)	–	(9)	–
TOTAL	185	101	64	100	79	100	78	100
Crashes after drinking								
Yes	14	8	4	7	5	6	32	44
No	152	92	51	93	73	94	40	56
Not applicable	(2)	–	(3)	–	(0)	–	(1)	–
Unknown	(17)	–	(6)	–	(1)	–	(5)	–
TOTAL	185	100	64	100	79	100	78	100
Number of MV convictions in the last 3 yrs.								
None	115	70	29	69	60	82	18	25
One	33	20	9	21	7	10	29	40
Two or more	17	10	4	10	6	8	25	35
Not applicable	(9)	–	(11)	–	(3)	–	(0)	–
Unknown	(11)	–	(11)	–	(3)	–	(6)	–
TOTAL	185	100	64	100	79	100	78	100
Number of suspensions								
None	149	90	39	95	66	90	16	23
One	13	8	2	5	7	10	24	34
Two or more	4	2	–	–	–	–	30	43
Not applicable	(9)	–	(12)	–	(3)	–	(3)	–
Unknown	(10)	–	(11)	–	(3)	–	(5)	–
TOTAL	185	100	64	100	79	100	78	100

Relative to the other groups on the *biographical variables*, the DWIs were generally older (Table III); were less well educated themselves and had parents who were also less well educated; were more likely widowed, separated, or divorced; were more likely unemployed; and were less likely to be students. Regarding the *driving variables* (Table IV), the DWIs reported having had more crashes after drinking and more license suspensions, as well as more crashes and more motor vehicle convictions in the previous three years. Furthermore, proportionally fewer DWIs reported having had a course in driver education. Regarding *drinking patterns* (Table V), the DWIs reported proportionally heavier consumption of beer, of liquor, and of their preferred beverage (which was most likely beer). Curiously enough, the DWIs showed themselves as having the highest proportion of individuals who did not drink wine (72%). Regarding the *accident attitude and alcohol attitude scales*, the DWIs for some inexplicable reason had smaller proportions of respondents above the cutting scores than was found among the other males. One could hypothesize that responses to the individual items comprising these two scales were relatively easy to fake, and that proportionally more of the DWIs were availing themselves of this opportunity. This question clearly merits more detailed investigation.

Factor Analyses

Several preliminary factor analyses were performed on subsets of the Driver Profile data to clarify the covariance structure of the variables involved. These included analyses on biographical variables, drinking variables, driving variables, and attitudinal items for a sample of the adult male Driver Profile respondents.

The 20 variables listed in Table VI were analyzed using a principal components solution, followed by varimax rotation of the first 5 components. The largest loading on a rotated component is presented in Table VI for each variable. With minor exceptions, the variables tend to correlate highly with only one component. The resulting groupings of variables seem eminently sensible.

As shown in Table VI, Factor A groups Quantity (Q) and Quantity-Frequency (QF) indices for beer and preferred beverage, indicating that Q and QF tend to measure the same thing, and that beer was usually the preferred beverage. Factor B groups the Q and QF indices for wine and liquor, along with education (higher education levels are associated with higher reported wine and liquor use), and the score on the DAS alcohol attitude scale (reported wine and liquor use is associated with higher values on the scale). Factor C groups the number of crashes, motor vehicle convictions, suspensions, and crashes after drinking, *i.e.*, the driving pattern variables. Factor D groups the biographical variables: age, mother's education, and marital status. Factor E associates the DAS accident attitude and violations attitude scores.

These 5 factors accounted for a total of 64.8% of the input variance, and the successive percentages of variance accounted for were: 25.6% = beer; 15.6% = wine, liquor, education level, and alcohol attitude score; 9.2% = driving record; 7.6% = age, mother's educational level, and marital status; and 6.8% = accident attitude score and violations attitude score.

Discriminant Analyses

The discriminant analyses were performed on the same set of variables as were the factor analyses, with the omission of Q and QF of preferred beverage and with group as the discriminating variable.

The first analysis included all 17 variables and was performed for all adult males. Because a complete data set was required, the potential pool of 398 cases was reduced to 130 cases since a great many individuals failed to respond to one or more items. While 130 cases apportioned into 4 groups is barely sufficient for a satisfactory discriminant analysis, it was felt that the advantage of including all variables outweighed

TABLE V *Beverage Consumption Quantity According to Reason for Examination and Outcome for Adult Males*

Type of Beverage	Operators				Fleet		DWI	
	Pass		Fail					
	N	%	N	%	N	%	N	%
Beer quantity								
None	23	14	16	29	6	8	4	6
1 - 2	36	21	14	25	22	28	13	20
3 - 4	38	22	19	34	27	34	19	29
5 or more	74	43	7	12	24	30	30	46
Not applicable	(0)	–	(0)	–	(0)	–	(0)	–
Unknown	(14)	–	(8)	–	(0)	–	(12)	–
TOTAL	185	100	64	100	79	100	78	101
Wine quantity								
None	52	32	33	64	26	35	42	72
1 - 2	55	34	13	25	28	38	11	19
3 - 4	39	24	4	8	15	20	3	5
5 or more	17	10	2	4	5	7	2	3
Not applicable	(0)	–	(0)	–	(0)	–	(0)	–
Unknown	(22)	–	(12)	–	(5)	–	(20)	–
TOTAL	185	100	64	101	79	100	78	99
Liquor quantity								
None	47	28	28	50	19	25	17	28
1 - 2	47	28	12	21	27	36	15	25
3 - 4	47	28	10	18	19	25	16	26
5 or more	26	16	6	11	10	13	13	21
Not applicable	(0)	–	(0)	–	(0)	–	(0)	–
Unknown	(18)	–	(8)	–	(4)	–	(17)	–
TOTAL	185	100	64	100	79	99	78	100
Preferred beverage quantity								
None	–	–	2	10	–	–	–	–
1 - 2	22	23	7	37	11	22	8	16
3 - 4	36	38	6	32	23	46	18	35
5 or more	36	38	4	21	16	32	25	49
Not applicable	(28)	–	(20)	–	(15)	–	(6)	–
Unknown	(63)	–	(25)	–	(14)	–	(21)	–
TOTAL	185	99	64	100	79	100	78	100

the potential hazards. In subsequent analyses, the variables dealing with preferences among alcoholic beverages and with the amounts consumed were deleted, thereby doubling the sample size.

This discriminant analysis produced a Mahalanobis $D^2 = 164.06$ which can be treated as a Chi-square with 51 df, and is significant at $p < .01$. Moreover, there were two significant roots, indicating that the groups can be discriminated on two dimensions. The results indicate that the DWIs tended to score higher than others on the driving-history variables. They also tended to be somewhat older, to have a lower level of education, and to drink relatively little wine. The Fleets tended to have few accidents, violations, or suspensions; were somewhat better educated than the Operator Passes and Fails; and drank somewhat more.

Subsequent analysis on subsets of the variables (chosen to increase the total sample size) produced similar results.

In all, a sequence of 6 discriminant analyses were applied to the adult male data in an attempt to discriminate among the 4 groups of respondents on the basis of 17 different predictor variables; and it was indeed possible in each case. The general finding that drivers convicted of DWI were older, less well educated, and had had more suspensions than others was common to all analyses in which these variables were involved.

TABLE VI *Varimax Rotated Factor Pattern, with only the largest Element in each Row shown*

Variables Analyzed	Factor				
	A	B	C	D	E
Crashes, last 3 years			.73		
Convictions, last 3 years			.81		
License suspensions			.78		
Crashes after drinking			.62		
Quantity: Beer	.91				
Quantity: Wine		.85			
Quantity: Liquor		.69			
Quantity: Preferred beverage	.91				
Quantity-Frequency: Beer	.92				
Quantity-Frequency: Wine		.82			
Quantity-Frequency: Liquor		.67			
Quantity-Frequency: Preferred beverage	.91				
Age				.75	
Educational level		.43			
Mother's educational level				–.52	
Marital Status				.73	
Alcohol attitude score (DAS)		.45			
Violation attitude score (DAS)					.83
Accident attitude score (DAS)					.81
Group (DWI, Fleet, Pass, Fail)		(All loadings small; $< .20$)			

Multiple Regression Analyses

In order to obtain an estimate of the possible utility and validity of the information from these selected variables, they were analyzed for relative importance in predicting an approximation of the criterion measures, namely, the number of after-the-fact self-reported crashes during the previous three years (Table VII) and the number of crashes after drinking (Table VIII). Accordingly, these same 17 variables, plus the seven Error Choice questions were regressed on these two criterion measures using the data from all adult male respondents. The variables which contributed to the regression are presented in Tables VII and VIII, and are arranged in descending order of standardized beta weight. The actual value of the standardized beta weight indicates the relative importance of the variable in predicting the criterion. High standardized beta weights indicate that a cue is both positively correlated to the criterion and is important in determining the criterion. Negative values of the standardized weights indicate that the predictor is negatively correlated with the criterion.

One important question concerns the value of an individual predictor in the regression equation apart from the simple ordinal measure obtained from comparing standardized beta weights. The F values presented in the regression tables indicate the strength of the hypothesis that the standardized beta weight is different from zero, that is, high values of F show that the beta weight *is* significantly different from zero.

A related question concerns the value of the regression equation taken as a whole in predicting the criterion, and this is addressed in the ANOVA summary tables at the bottom of Tables VII and VIII. These Tables show the sum of squares due to regression (or the predictable variance) versus the unexplained (or error) variance. The significant F values in the case of both criterion measures indicate that the regression equations are able to predict a significant amount of the variance, and that the regression equations have some predictive utility.

Regarding Table VII, "crash after drinking" has the highest beta weight and therefore is the best single predictor of the total number of crashes in the last three years (which were used as the criterion in this regression). Age shows the same approximate level of predictive importance, but the negative sign indicates that younger males tended to have more crashes than older males. Although the next three variables are statistically significant, the beta weights are relatively low in an absolute sense and might therefore be interpreted as having little practical importance. However, the other analyses discussed above, as well as the results of several studies cited earlier, would imply that these variables (number of citations in the last three years; marital status; and even the number of license suspensions) would probably be useful predictors, especially if used in conjunction with some of the other important variables.

Regarding Table VIII, a different pattern emerges with age regressed on crashes after drinking, namely, older males tended to have more such crashes than younger males. Furthermore, the combined driving record of crashes, violations, and suspensions becomes a significant factor in predicting crashes after drinking. Finally, regarding the drinking patterns, the quantity of beer and quantity of wine typically consumed both show significant predictive importance and in the opposite directions, which is consistent with self-reports by DWIs. More specifically, DWIs significantly outdid individuals in other categories when it came to the quantity of beer usually consumed. Conversely, however, DWIs reported drinking significantly less wine than the other groups.

TABLE VII *Multiple Regression Analysis: Regression of Variables on Number of Reported Crashes in the Last Three Years for All Adult Male Respondents*

Variable	Beta	F (df = 1,299)
Crash after drinking	.33	38.1*
Age	–.30	22.7*
Error Choice Q116 (People who take risks)	–.13	7.2*
No. citations, last 3 years	.17	5.8**
Marital status	.13	4.8**
No. license suspensions	.14	3.7
Error Choice Q117 (SBs reduce injury by)	.09	3.5
Mother's education	.07	2.0
Quantity liquor	.08	1.9
DAS Accident Scale	.07	1.7
Error Choice Q122 (DWI limit should be)	.06	1.5
Error Choice Q119 (Most accidents due to)	–.06	1.3
Quantity: Wine	.06	1.1

ANOVA Summary Table

	df	Mean Square	F
Regression	13	1.75	11.53*
Residual	299	0.15	

NOTE: Only those variables which contribute to the regression are tabulated.
$F_{(1,200,.05)} = 3.89$ $F_{(1,200,.01)} = 6.76$
$*p < .01$ $**p < .05$

CONCLUSIONS AND RECOMMENDATIONS

A preliminary assessment of the utility and the validity of the Driver Profile was possible despite some of the limitations of the present data. On the basis of the consistent and significant results from the 4 different statistical analyses reported above, it can be concluded that this psychometric approach to identifying highrisk drivers is technically feasible and appears to be sufficiently valid to warrant continued refinement for wider implementation.

On the basis of the many analyses and experiences to date, a number of specific conclusions and recommendations can be made:

TABLE VIII *Multiple Regression Analysis: Regression of Variables on Crash After Drinking for All Adult Male Respondents*

Variable	Beta	F (df = 1,302)
Combined crashes, violations, suspensions	.24	19.9*
Age	.25	14.8*
Error Choice Q119 (Most accidents due to excessive)	.15	8.2*
Quantity: Beer	.15	6.0**
Quantity: Wine	–.13	4.5**
Mother's education	–.09	2.5
Quantity: Liquor	.10	2.5
Education	–.09	2.0
Violation Scale (DAS)	–.06	1.3
Marital status	–.07	1.2

ANOVA Summary Table

	df	Mean square	F
Regression	10	.786	8.19*
Residual	302	.096	

NOTE: Only those variables which contribute to the regression are tablulated.
$F_{(1,200,.05)} = 3.89$ $F_{(1,200,.01)} = 6.76$
$*p < .01$ $**p < .05$

1. Since the Driver Profile questionnaire as used in the present study is longer than absolutely necessary, it could be shortened. That is, sufficient preliminary evidence is currently available to support a decision to reduce the number of items at this time. For example, the current version could be substantially reduced by eliminating selected items from the Driver Attitude Survey, which did not begin to contribute in proportion to its relative size in the Driver Profile questionnaire.

2. Since the error-choice questions seem to be effective in differentiating the various categories of respondents, any revised version of the Driver Profile questionnaire should include more items from the Vermont Error-Choice Test of Driving Skill. In fact, it would seem highly desirable to include this test in its entirety in order to increase the apparent plausibility for the respondent by offering him a number of questions for which a correct response option is available.

3. It is recommended that new scales be developed from the existing Driver Profile data which would cut across all items in the total pool. The predictive strength of the Driver Profile could be appreciably increased by this means.

In conclusion, it seems clear from a review of the previous and present attempts to develop a "predictive psychological-biographical profile of high-risk drinking drivers" that steady, step-by-step progress is being made toward achieving the objectives. Among other contributions, the original Project ABETS study (29) was successful in developing questionnaires, procedures, and analyses which were capable of correctly classifying 95% of the clear-record drivers and 87% of the convicted DWI drivers using four significant variables: lifetime motor vehicle citations, occupational level, beer frequency, and liquor quantity.

The present study represents another major step forward through its demonstration of the administrative and technical feasibility of testing large numbers of respondents at motor vehicle examining stations. It also provides a demonstration of the increased utility for identifying high-risk drinking drivers which can be accomplished by including highly structured, but 'disguised' attitudinal (error-choice) questions in the instrument. In view of the progressive refinement which has occurred to date, the next step in the series seems quite clear, namely, refining the procedures even further through the use of multivariate statistical analyses in conjunction with validating data obtained from actual driving experience. Then, the next major step after that would consist of having a brief, highly tailored, validated instrument which could be handed over to the motor vehicle departments for use in screening would-be drivers.

SUMMARY

The basic question in driver examination programs is concerned with the utility of licensing examinations as a means to the end of identifying driver applicants who would most likely have crashes if allowed to participate in the driving society. However, taking the crash as the ultimate criterion measure means not only using a rare event, but also one which occurs only *after* the applicant has been tested and licensed. Thus, all attempts at evaluation tend to be "after-the-fact" studies. Therefore, it is necessary to obtain *intermediate* measures which have at least a correlational association with the ultimate criterion measure.

The specific aims of this study included developing a questionnaire for identifying the problem-drinking driver on the basis of psychological-biographical variables, and evaluating its effectiveness as a screening and diagnostic instrument for identifying probable high-risk drinking drivers in order to refer them for special aid. The rationale for this psychometric approach is based upon the assumption that individuals who subsequently become labeled as "bad" or high-risk drivers in terms of the ultimate criterion variables of crashes and citations differ systematically on some combination of biographical, attitudinal, and personality variables which can be measured before the fact (*i.e.*, at the time of the licensing examination).

In conjunction with the Vermont Department of Motor Vehicles, the official licensing examination was given to a sample of 840 applicants. This sample was comprised of applicants for learners and for operators licenses, as well as state employees and DWIs. A control sample of 1,283 applicants was obtained for comparison purposes.

Within- and between-group analyses were conducted. The most significant results from the first stage of this study stem from attempts to establish relations between responses on probable predictor variables and the available validity criteria, *i.e.*, the self-reported driving records of previous crashes, citations, and suspensions from those individuals with prior driving experience. The most important of these findings for all

the male operators (excluding learners) are: (a) significant variables regressed on number of *crashes in last 3 years* (in order of decreasing *F*): crashes after drinking, age (negative), risky error-choice (negative), number of citations in last 3 years, marital status, and number of license suspensions; (b) significant variables regressed on *crashes after drinking*: combined crashes, violations, and suspensions, age, risky error-choice, beer quantity, and wine quantity (negative); (c) factor analysis indicated the following 5 factors accounted for 65% of variance: 26% = beer (Quantity, Quantity-frequency, and as Preferred Beverage), 16% = wine and liquor (Q and Q-f), education, and alcohol attitude (high values on each variable associated with high values on each other variable), 9% = driving record (crashes, convictions, suspensions, crashes after drinking), 8% = mother's education, and marital status, 7% = attitudes toward accidents and violations.

DWIs versus all other groups. The DWIs differed from the others on almost every variable analyzed. As a group, they were generally older, less well-educated themselves, and had parents who were also less well-educated; more likely widowed, divorced, or separated; and more likely unemployed. Regarding *drinking variables*, DWIs reported having had more crashes after drinking, more license suspensions, and more crashes and citations in previous 3 years. Regarding *drinking patterns*, DWIs reported heavier consumption of beer, liquor, and preferred beverage (which was typically beer), but highest proportion of individuals who do not drink wine.

General conclusion. This psychometric approach to identifying high-risk drinking drivers is technically feasible, and appears sufficiently valid to warrant continued refinement for wider implementation.

REFERENCES

1. Barmack, J. W. and Payne, D. E., Injury-producing Motor Vehicle Accidents among Airmen. I. The Role of Drinking. *Highway Research Board Bulletin* 285, 1-11 (1961).
2. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B. and Zylman, R., *The Role of the Drinking Driver in Traffic Accidents.* Department of Police Administration, Indiana University, Bloomington, Indiana, 1964.
3. Burg, A., The Stability of Driving Record Over Time, *Accident Analysis and Prevention* 2, 57-65, (1970).
4. Campbell, B. J. and Levine, D., Accident Proneness and Driver License Programs. *Proceedings of the 1st International Conference on Driver Behaviour*, International Drivers' Behaviour Research Association, Courbevoie, Paris, France, 1973.
5. Carlson, W. L., Alcohol Usage of the Nighttime Driver, *Journal of Safety Research* 4, 12-25 (1972).
6. Carlson, W. L., Age, Exposure, and Alcohol Involvement in Night Crashes, *Journal of Safety Research* 5, 247-259 (1973).
7. Carlson, W. L., Chapman, M. M., Clark, C. D., Filkins, L. D. and Wolfe, A. C., Washtenaw County BAC Roadside Survey. Report #HSRI-71-126, Highway Safety Research Institute, University of Michigan, 1971.
8. Clark, Cheryl D., A Comparison of the Driving Records and Other Characteristics of Three Alcohol Involved Populations and a Random Sample of Drivers. Highway Safety Research Institute, University of Michigan, *HIT LAB Reports* 2(10), 1-5 (1972).
9. Clark, C. D., Compton, M. J., Douglass, R. L. and Filkins, L. D., A Three Year Comparison of Alcohol Related Driving Behavior in Washtenaw County, Michigan. Highway Safety Research Institute, University of Michigan, *HIT LAB Reports* 4(2), 1-14 (1973).
10. Cosper, R. and Mozersky, K., Special Correlates of Drinking and Driving, *Quarterly Journal of Studies on Alcohol, Supplement No. 4*, 58-117, (1968).
11. Didenko, O. R., McEachern, A. W. and Berger, R. M., *Drinking Driver and Traffic Safety*

Project. Vol. I. National Highway Traffic Safety Administration, Technical Report, DOT HS-800-699, 1972.

12. Filkins, L. D., Clark, C. D., Rosenblatt, C. A., Carlson, W. L., Kerlan, M. W. and Mason, H., *Alcohol Abuse and Traffic Safety: A Study of Fatalities, DWI Offenders, Alcoholics, and Court-related Treatment Approaches*. U.S. Department of Transportation, National Highway Safety Bureau, Technical Report, FH-11-6555 and FH-11-7129, 1970.

13. Harano, R. M., McBride, R. S. and Peck, R. C., *The Prediction of Accident Liability Through Biographical Data and Psychometric Tests.* Department of Motor Vehicles, Highway Research Report B0132, California Division of Highways, Sacramento, March 1973.

14. Hurst, P. M., Estimating the Effectiveness of Blood Alcohol Limits. In *Alcohol, Drugs, and Driving*, M. W. Perrine (Ed). National Highway Traffic Safety Administration, Technical Report, DOT HS-801-096, 1974.

15. Hyman, M. M. Accident Vulnerability and Blood Alcohol Concentrations of Drivers by Demographic Characteristics, *Quarterly Journal of Studies on Alcohol, Supplement No. 4*, 34-57 (1968).

16. Hyman, M. M., The Social Characteristics of Persons Arrested for Driving While Intoxicated, *Quarterly Journal of Studies on Alcohol*, *Supplement No. 4*, 138-177 (1968).

17. Kaestner, N. and Speight, L., Multivariate Predication of Drinking Drivers. Paper presented at the Western Psychological Association Annual Meeting, Annaheim, California, April 1973.

18. McGuire, F. L., The Understanding and Prediction of Accident-producing Behavior. In *Highway Safety: Anatomy of a Problem*, Patricia F. Waller (Ed). Vol. 1. *North Carolina Symposium on Highway Safety*. University of North Carolina Press, Chapel Hill, North Carolina, 1969.

19. Mortimer, R. G., Filkins, L. D., Kerlan, M. W. and Lower, J. S., Psychometric Identification of Problem Drinkers, *Quarterly Journal of Studies on Alcohol* 34, 1332-1335 (1973).

20. Perrine, M. W., Identification of Personality, Attitudinal, and Biographical Characteristics of Drinking Drivers, *Behavioral Research in Highway Safety* 2(4), 207-226 (1970).

21. Perrine, M. W., *Methodological Considerations in Conducting and Evaluating Roadside Research Surveys*. National Highway Traffic Safety Administration. Technical Report, DOT HS-800-471, 1971.

22. Perrine, M. W., Psychological-biographical Correlates of Problem Drivers and Drinking Drivers. *Proceedings of the 3rd Triennial Congress of the International Association for Accident and Traffic Medicine*. University of Michigan Press, Ann Arbor, Michigan, 1971.

23. Perrine, M. W., The Driver Profile: Using Driver Licensing as a Countermeasure for Highway Crashes Involving Alcohol. *Proceedings of the Department of Transportation Forum on Traffic Safety Alcohol Countermeasures*. Washington, D. C. 1971.

24. Perrine, M. W., The Spectrum of Drinking Drivers. In *Alcohol and Highway Safety*, Patricia F. Waller (Ed). Vol. 3. *North Carolina Symposium on Highway Safety*. University of North Carolina Press, Chapel Hill, North Carolina, 1972.

25. Perrine, M. W., *The Vermont Driver Profile: A Psychometric Countermeasure for Early Identification of Potential High Risk Drivers*. National Highway Traffic Safety Administration, Technical Report, DOT Contract FH-11-7543, 1973.

26. Perrine, M. W., Alcohol and Highway Safety. In *Alcohol and Health: Special Report to the U. S. Congress* (2nd ed), Secretary of Health, Education, and Welfare (Ed). DHEW Publication; U.S. Government Printing Office, Washington, D. C. 1974.

27. Perrine, M. W., Alcohol Involvement in Highway Crashes: A Review of the Epidemiologic Evidence. In *Clinics in Plastic Surgery*, R. D. Schultz (Ed). M. B. Saunders, Philadelphia, 1974.

28. Perrine, M. W., A Typology of Alcohol Users from the Traffic Safety Point of View. *Proceedings of the 1st International Conference on Driver Behaviour*. International Drivers' Behaviour Research Association, Courbevoie, Paris, France, in Press.

29. Perrine, M. W., Waller, J. A. and Harris, L. S., *Alcohol and Highway Safety: Behavioral and Medical Aspects*. National Highway Traffic Safety Administration, Technical Report, DOT HS-800-599, 1971.

30. Reese, J. H., *Power, Policy, People: A Study of Driver Licensing Administration*. Highway Research Board Special Report 123, National Academy of Sciences, 1971.

31. Schuster, D. H. and Guilford, J. P., *The Driver Attitude Survey*. Sheridan Psychological

Supply, Beverly Hills, California, 1962.

32. Waller, J. A., Identification of Problem Drinking Among Drunken Drivers, *Journal of the American Medical Association* 200, 114-130 (1967).

33. Waller, J. A., Administrative and Research Problems in Identifying Individuals with High Crash Risk, *Behavioral Research in Highway Safety* 1, 67-77 (1970).

34. Waller, J. A., King, E. M., Nielson, G. and Turkel, H. W., Alcohol and Other Factors in California Highway Fatalities, *Journal of Forensic Sciences* 14, 429-444 (1969).

35. Zylman, R., Accidents, Alcohol and Single Cause Explanations: Lessons from the Grand Rapids Study, *Quarterly Journal of Studies on Alcohol, Supplement No. 4*, 212-233 (1968).

36. Zylman, R., Youth, Alcohol, and Collision-Involvement, *Journal of Safety Research* 5, 58-72 (1973).

Mass Arrests for Impaired Driving May Not Prevent Traffic Deaths

Richard Zylman[1]

Conferences such as the 6th International testify to the fact that those who abuse the use of alcohol and then drive continue to plague every nation. Each conference in this series has signified new accomplishments in developing techniques to identify, arrest and test the alcohol-impaired driver, and each conference brings to light new problems which have developed because those new techniques did not accomplish their intended purpose.

For example, the widespread use of breath testing instruments did not result in a large reduction in traffic deaths. Nor did the enactment of implied consent laws or presumptive and *per se* laws with lower limits have their planned impact. Pressure to identify and remove all problem drivers from the highway did not reduce the number of traffic deaths. The problem of the impaired or intoxicated driver continues to be reported as a factor in almost half of all traffic deaths in the United States in spite of costly and increasingly sophisticated countermeasure programs, and in spite of massive numbers of arrests for alcohol related offenses. The time has come to stand back and ask, Why?

Cut the Problem Down to Proper Size

Initially, it must be pointed out that part of the reason why progress cannot be measured is that the problem has been so poorly defined. Statements to the effect that alcohol is involved in 50 per cent of all traffic deaths are usually based on incomplete and biased data (24) and include blood alcohol concentrations (BACs) as low as 10 to 40 mg/100 ml; levels shown by epidemiological study as not having a causal relationship to crash involvement (22). Extensive reviews of the literature reveal that the number of traffic deaths that may involve alcohol in some causal fashion may be closer to 30 per cent than to 50 per cent (24, 25, 26). It is difficult to measure the extent to which a problem is being solved if that problem, at least in part, does not exist.

Fatal Crashes are Different from Run-of-the-Mill Collisions

It is widely believed that fatal crashes are a part of a continuum that includes even the minor run-of-the-mill collisions; *i.e.*, that if collisions-in-general can be prevented, fatal crashes will be prevented. This belief is expressed in the widespread use of the curve from the Grand Rapids Study (1) which indicates that the probability of causing a collision at 60 mg/100 ml is twice what it would be if one had not been drinking; the probability at 80 mg/100 ml is 4 times as great; at 100 mg/100 ml, 6 or 7 times as great; and that at a BAC of 150 mg/100 ml or more, the likelihood of causing a crash is 25 times greater than if one had not been drinking.

---

[1] Associate Research Specialist, Center of Alcohol Studies, Rutgers, The State University of New Jersey, New Brunswick, New Jersey

It should be noted that that probability curve is based on collisions-in-general; the kind that most of us or members of our family may be involved in. They result from inadvertance, inattention or inexperience. More than two-thirds of the collisions in the Grand Rapids Study occurred between 6 a.m. and 6 p.m., two-thirds of those collisions resulted in damage under $300, 89 per cent did not incur visible injury, and the majority of them occurred in business or densely traveled lower class residential neighborhoods; the balance occurred in better class urban residential areas. In addition, only 7 per cent of the drivers in non-injury collisions had a BAC of 50 mg/100 ml or more, and 14 per cent of those in serious injury collisions had BACs in that range.

In contrast, most fatal crashes occur at night, in non-business areas, frequently involve total demolition of the vehicle and, by definition, are fatal. In addition, approximately 44 per cent of all drivers killed have a BAC of 100 mg/100 ml or more (2). It should also be noted that, although the Grand Rapids Study established 80 mg/100 ml as the level at which alcohol becomes a statistically significant factor in collisions-in-general, the level at which alcohol becomes a statistically significant factor in fatal crashes has not been established on the basis of controlled epidemiological studies (26). For these reasons and others, fatal crashes should be considered as being quite different from collisions-in-general; they probably require different countermeasures.

Not all Problem Drinkers are Problem Drivers

It has become popular in the last few years to blame an ever increasing number of fatal crashes on "problem drinkers." The distinction between problem drinkers and alcoholics is a semantic conundrum that will not be discussed at great length in this paper. It is agreed, however, that in the broader sense, the term includes those whose excessive drinking results in auto crashes. For most people, however, the term "problem drinker" suggests alcoholism.

Regardless of the definitions used for problem drinking or alcoholism, it should be recognized that this is not merely a game of semantic gymnastics. We are talking about people who already have problems beyond their limits of coping. Historically, alcoholics and alcoholism have been the scapegoat for many of society's problems. It is not surprising then, that because identifiable alcoholics are found among drivers who have been drinking before their fatal crash and among those convicted of driving while impaired or intoxicated (DWI), that more and more of the blame for these social ills is placed on the alcoholic. There seems to have been such an obsession to link alcoholism to fatal crashes and drunken driving offenses that the fact that many alcoholics do not come in contact with the police and are not involved in collisions has been overlooked. Instead, they are grouped as a class to be labeled, listed and restricted or removed from the road (16), or, as implied in the newly resurrected Saturday Evening Post (3), these "killer drunks" must be rehabilitated because "there are not enough jails in the country to hold all our alcoholics." (p. 65).

It is easy enough to cite a number of studies showing that alcoholics, as a group, are involved in more collisions than non-alcoholics, are arrested more often for DWI and other alcohol related offenses, and that they have their driver licenses suspended more often; this is no surprise. It has also been shown that drivers with high BACs are more likely to show symptoms of alcoholism; that too, is no surprise. What may be surprising to some people is that (a) not all alcoholics drive, (b) not all alcoholics who do drive, drive while drunk – either some of the time or all of the time, (c) that not all alcoholics are dangerous, and (d) that not all alcoholics have long records of collision-involvement and police contacts.

Filkins *et al* (6) studied 1,247 hospitalized alcoholics who were known to be drivers and found that 86 per cent of them had not been involved in more than one collision in the 6-year study period; 83 per cent had neither a DWI charge nor more than one driving conviction in the 6-year period.

Selzer *et al* (12) studied 50 alcoholics and found that the majority of them had not been involved in more than 2 collisions in their lifetime – a record many of us envy.

Recalculation of data presented by Schmidt and Smart (11) reveals that among 98 alcoholics known to be drivers, there were only 79 reported collisions over a 12-year period. Granted, this was significantly more collisions than were experienced by the general driving population, but still averaged less than one collision every 12 years for each alcoholic.

Clay (5) examined the driver and hospital records of nearly 1,400 hospitalized alcoholics and reported that:

> *...from a total sample of 1,273 chronic alcoholic drivers, 94 (7%) probably qualify as prime candidates for a traffic safety countermeasures program. The other 1,179 according to their driving records, drive much like the rest of us. At most, if we include medium risk drivers, we should be concerned about the driving habits of only 34 per cent.* (p. 44)

Regardless of which study is considered, the majority of alcoholic drivers are not known to police and are not involved in serious crashes.

It Takes more than Alcohol

We would do well to heed the words of Selzer and Chapman (14):

> *Many studies have implicated the alcoholic driver as a significant contributor to injury and fatal traffic accidents. Various characteristics including impulsivity, suicidal proclivity, paranoid ideation, depression and anxiety have been suggested as attributes of a traffic-accident-prone personality. Other studies have shown that social stress is an important variable in the causation of accidents. Since the knowledge of the presence of alcoholism alone is not sufficient, it is obvious that our next task is to develop practical means of identifying the high risk alcoholic driver, preferably before he makes his mark on the highway.* (p. 212)

Brenner and Selzer (2) put it this way.

> *A study of disturbing events as a factor in accidents, and of alcoholism as a factor in disturbing events, is needed not only to explore whether certain*

> *types of disturbing events provide one of the mechanisms whereby alcoholism can increase accident risk, but also to determine whether the estimated effect of alcoholism on accident risk is inflated by the effect of disturbing events which are more frequent among alcoholics but which cannot be said to be caused by alcoholism.* (p. 495)

Zelhart (21) examined the collision and arrest records of the three groups of alcoholics defined by Lawlis and Rubin (7). The groups were identified as group X, described as inhibited and frustrated; group Y, described as lacking the ability to interact socially; and group Z, described as unsocialized and aggressive. Zelhart found that the alcoholics in group Z had the highest frequency of traffic citations, suggesting that unsocialized, aggressive individuals may be potentially the most dangerous drinking drivers. Alcoholics with the fewest citations could be characterized as apprehensive, more emotionally stable, more self-sufficient and less impulsive. Zelhart concluded:

> *For practical purposes, the results indicate that not all alcoholic drivers may be equally dangerous. Additional research, using a wider variety of subjects and test measures, may be able to specify the 'high risk' alcoholic driver by means of personality characteristics.* (p. 813)

Clay (5) reported:

> *The evidence at least suggests that our index is measuring a potential for risk-taking behavior which may exist in a person independently of his use of alcohol and which manifests itself as aggressive irresponsibility. Such people may frequently use their cars as weapons rather than as means of transportation. The role of alcohol with such a person may simply be to more readily allow expression of that potential. If our speculation is true, then the high-risk drinking driver may be a very different kind of problem than we thought, and the countermeasures needed to change or control his pathology may be different than those we're currently using.* (p. 46)

In summary, not all alcoholics are dangerous. Each of the researchers cited above suggests that there are characteristics or conditions other than alcoholism necessary to make high-risk drivers; or that alcoholism is only one characteristic found among high risk drivers.

Youth

It is currently popular to point to youth as comprising a large portion of all drinking drivers in fatal crashes. That is a correct appraisal but should be used with caution. First, it is an injustice to classify all drivers under the age of 25 in one group to be castigated as 'youth'; it is an injustice to the many drivers who are 15 to 17 years old, and somewhat less of an injustice to those who are 18 or 19. It has been found repeatedly that the drinking and driving habits and crash involvement of drivers 20 to 24 years old are very different from those who are younger (8, 9, 23).

It should be remembered that the majority of youth use alcohol to some degree by the time they reach 18, but relatively few of them drive after drinking. Pelz *et al* (9) interviewed and examined the records of nearly 1,700 young men regarding their use of alcohol as it related to collision involvement and reported:

> *. . .frequency and amount of drinking were found mildly related to crashes in the past year, and more definitely to violations-plus-warnings (both adjusted for exposure). However, these effects were mainly noticeable in about one-third of the young male sample who expressed strong social antagonism – either alienation from the school system, or hostility toward people around them. In the absence of such antagonism, frequency or amount of drinking bore little relationship to driving record. Alcohol thus appeared to have an indirect effect on dangerous driving, by releasing aggressive impulses in a minority of young men.* (Pre publication mimeograph).

Pelz and his colleagues make it clear that it is not alcohol, per se, that leads to crashes, but alcohol in combination with other characteristics that makes for high-risk drivers.

Not all Drunks are 'Killer Drunks'

It is becoming increasingly evident that not all drivers arrested for DWI are "killer drunks." It has been shown above that even if all persons arrested for alcohol-related violations were alcoholic, (which they are not), there would still be a large proportion who could not be classified as dangerous.

Empirically, it can be stated that the majority of drivers arrested for impaired driving are not found careening down the road at high speed, nor are they pulled from violent wrecks. They are more likely to have been fumbling along, slowly attempting to negotiate their trip without incident, having frequently driven a number of miles in an impaired condition. In some cases they are found asleep in their motor-vehicle. Those who are arrested after being involved in collisions are most often involved in minor affairs resulting from miscalculation; such as low speed rearend collisions, side-swipes and clipping parked cars.

In contrast, those involved in fatal crashes have frequently been driving at high speed, and retrospective studies indicate that many of them endured traumatic or extraordinary emotional experiences during the hours of days before the crash, or that they displayed symptoms of mental aberrations (4, 13). This suggests a need to study the differences between those arrested for DWI after high speed chases and the fighting drunks on the one hand, and the average, docile, cooperative drunk on the other. It may be among the fighting drunks that characteristics will most closely coincide with those involved in serious crashes.

Another reason to suspect that we may be arresting the wrong drunks is that so few of them act like killer drunks. It is common practice in the United States, and perhaps in other countries, to make the arrest, complete the testing and booking and then release the DWI driver to some responsible party, e.g. wife or brother-in-law. Many such drivers are arrested with BACs of 200 to 250 mg/100 ml and then released an hour or two later when they could still have a BAC of 170 to 200 mg/100 ml or more. If one assumes that these miscreants are irresponsible killer drunks it would also be logical to assume that some of them drive again the same night regardless of the fact that they are supposed to be released to responsible parties and told not to do so. However, they apparently do not become involved in serious crashes. If they did there would be large bold headlines in the newspapers and the aggrieved parties would bring suit against the police and the city or state for dereliction of duty in releasing such a killer drunk while he still had an impairing amount of alcohol in his system. The fact that this has apparently not been happening suggests to the present writer that we may be arresting the wrong drunks; that those involved in serious crashes while drunk are, by and large, different from those being arrested for DWI. It suggests that fatal crashes are different from run-of-the-mill collisions and that mass arrests of the conventional drunken driver will not prevent traffic deaths.

Filkins *et al* (6) and Perrine *et al* (10) found substantial similarities between drivers who were killed with high BACs and those who were arrested for DWI. However, there were also important differences. Fatality drivers were generally younger, of higher socio-economic status, less likely to have records of prior arrest, and had fewer prior collisions.

Thomas and Chang (15) compared the records of drivers who died after drinking with records of convicted DWIs who had been involved in prior crashes, and even between these presumably similar groups found highly significant differences. The authors, considering the very high rate of recidivism among convicted DWIs and the relatively infrequent prior convictions of deceased DWIs, went so far as to suggest that "present countermeasure programs are seen as inefficient ways of reducing death on the highways." These findings further support the theory that we are arresting the wrong drunks if it is the serious and fatal crashes we wish to prevent.

Evidence in Current Programs

In the United States 29 areas were selected for concentrated community-centered, federally funded Alcohol Safety Action Programs (ASAPs) to combat those who drink to excess before driving. In general, these projects involve special training for police, prosecutors, judges, and community leaders, as well as widespread public education programs. Additional police patrols, screening and rehabilitation programs have also been instituted. Such programs have now been operational for two years. In spite of massive increases in arrests and prosecution, no important and lasting changes can be seen.

In an evaluation of those programs, officials cautiously attribute a small decrease in nighttime fatal crashes to the countermeasure programs:

> *In the ASAP communities there was no significant reduction in daytime crashes when compared to the three baseline years. It is possible, however, that the ASAPs had some impact in holding down in these communities the national upward trend in all fatal crashes. This difference is too small to be statistically significant with the amount of data available at this time. Until additional data become available, there is no statistically significant evidence for impact during either night or day for the 21 projects for which only one year of operational data are available. On the other hand, it does appear that a small but significant reduction in fatalities has occurred which can be attributed to ASAPs at those 8 projects with two full years of operations.* (17, p. 73)

In a later evaluation comparing the three-year baseline experience with two full operational years in the 29 ASAP areas, it was reported that, ". . .under the most conservative assumption it appears that at least a 6 per cent reduction in alcohol-related crashes is being achieved, while at the other end of the continuum as much as a 19 per cent reduction may be occurring." (18, p. 15)

Zador (20) evaluated the effectiveness of these programs on the basis of comparable areas used as controls, and refutes even this minimal claim for success: "In view of the results of the several detailed analyses presented in this paper, and in the absence of any evidence of an overall reduction in fatalities, it is only possible to conclude scientifically that ASAPs, as large scale social programs, have been ineffective."[2] (Pre publication mimeograph).

Whether or not the improvement attributed to the ASAP programs is real is not the issue in the present discussion, but rather, whether the change, if any, is due to an increase in enforcement of alcohol related laws.

Although it may be believed by some that the meager improvement in fatal crashes attributed to the ASAP programs is a result of the vastly increased enforcement programs, it is stated officially that:

> *The overall relationship of arrest activity. . .vs changes in fatal crash data for the projects, yielded no statistically significant results. . . .It is possible that the arrest levels in the ASAPs are still below the level needed to be a deterrent by themselves. This hypothesis is supported by an analysis of arrest data per licensed driver which shows that seven of the ten projects with the highest arrest rate still reported an increase in fatal crashes. In addition, five of the ten projects with the largest increase in arrests still reported increases in fatal crashes.* (1, pp. 101-102)

In the more recent evaluation it was stated that,

> *No evidence of a relationship between alcohol-related arrest activity and the change in level in nighttime fatal crashes was found in an analysis of data from the 29 ASAPs.* (18, p.11)

For purposes of illustration the 29 ASAP sites have been arranged in the order of the largest increase in alcohol-related arrests over the two year period (Table I); those showing the largest increase are first. They were then divided into four groups designating (a) those sites where the number of arrests increased by 300 per cent or more; (b) those areas where the number of arrests was increased by 200 to 300 per cent; (c) those areas in which the number of arrests was increased by 100 to 200 per cent; and (d) those areas in which there was an increase of less than 100 per cent over the two year period. In the same Table, the average number of fatal nighttime crashes during three baseline years are shown in comparison with the number of such crashes during the operational year.

Although it has traditionally been believed that massive numbers of arrests will lead to fewer alcohol-related fatal crashes, that belief is not substantiated by the data presented in this Table. It can be seen that in those areas included in group *a* where arrests for alcohol-related offenses increased by an average of 500 per cent, the number of nighttime fatal crashes actually increased by more than 4 per cent. In group *b*, among those communities where enforcement increased by an average of 245 per cent, there was a 2 per cent drop in nighttime fatal crashes. In group *c*, with an average increase of 140 per cent the number of nighttime fatal crashes went down by 4.5 per cent and in group *d*, with an average increase in arrests of only 74 per cent, the reduction in traffic deaths was nearly 8 per cent. Thus, exactly the opposite of

---

[2] The present writer has been informed by a number of sources that Zador's study has been challenged by the Department of Transportation. However, the official announcement is not available at this writing.

TABLE I *Distribution of ASAP areas by percentage increase in alcohol-related arrests and change in nighttime fatal crashes in per cent*

Areas	1970 Alcohol Related Arrests	Operational Year Alcohol Related Arrests	Per cent Increase	Baseline Years Average Fatal Crashes	1972 Fatal Crashes	Per cent Change
Group A – *Showing more than 300 per cent increase in arrests*						
Fairfax Co., Va.	82	2943	3490	38.7	36.0	–7
Cincinnati, O.	527	2906	451	39.0	41.0	+5
Pulaski Co., Ark.	963[a]	5759	498	19.3	19.0	–2
Tampa, Fla.	1157	6249	440	58.3	64.0	+10
San Antonio, Tx.	1137	5346	370	47.0	51.0	+9
	3866	23203	500.2	202.3	211.0	+4.3
Group B – *Showing 201 to 300 per cent increase in arrests*						
Albuquerque, N.M.	987	3686	273	34.3[a]	46.5[b]	+36
New Orleans, La.	1211	4217	248	47.0	33.0	–30
Indianapolis, Ind.	1352	4474	231	28.7	31.0	+8
Vermont	293	928	217	15.7	15.0	–4
Wisconsin	290	885	205	21.7	19.0[b]	–12
	4133	14190	243.3	147.4	144.5	–2.0
Group C – *Showing 101 to 200 per cent increase in arrests*						
Phoenix, Ariz.	3408	10095	196	46.3	51.0	+10
South Dakota	1282	3640	184	91.0	108.0	+19
Portland, Ore.	1612	4379	172	29.3	23.0[b]	–22
Oklahoma City, Ok.	1359	3635	167	30.0	37.0	+23
Wichita, Kan.	479	1272	166	24.0	20.0	–17
Columbus, Ga.	1469[a]	3722	153	8.7	8.0	–8
Lincoln, Neb.	375[a]	930	148	6.0	5.0	–2
Denver, Col.	2626	6423	145	59.7[b]	55.0[b]	–8
Kansas City, Mo.	2272	5054	122	45.7	49.0	+7
Seattle, Wash.	4596	9774	113	94.3	65.5[b]	–31
Charlotte, N.C.	2065	4355	111	37.0[a]	32.0[b]	–14
New Hampshire	2677[a]	5528	106	78.0	72.0	–8
Nassau Co., N.Y.	2047	4120	101	79.0	75.5[b]	–4
	26267	62927	139.6	629.0	601.0	–4.5
Group D – *Showing less than 100 per cent increase in arrests*						
Richland Co., S.C.	1351[a]	2682	99	23.3	16.0	–31
Baltimore, Md.	2133	4051	90	69.7	78.0	+12
Washtenau Co., Mi.	677	1225	81	31.0[b]	26.5[b]	–15
Portland, Me.	1236	2401	94	29.3	23.0	–22
Boston, Mass.	657	874	33	47.7	44.0	–8
Hennepin Co., Minn.	3427	5233	53	41.7	36.0	–14
	9481	16466	73.7	242.7	223.5	–7.9

[a] 1971 Figures
[b] 2-year averages
Source: Figures 57, 58 Evaluation of questions and figure 3, Evaluation of Enforcement of reference (17).

traditional expectation actually occurred; the best reduction in nighttime fatal crashes was recorded in communities where enforcement was increased the least, and, conversely, there was an increase in the number of such crashes where the number of alcohol related arrests had increased the most – from 370 to more than 3000 per cent.

It may be argued that the reason for this anomaly is that those communities with an already high enforcement rate would be least likely to increase the number of arrests; *i.e.* it is the overall rate that is important, not the short term increase in arrests.

This is only partially true. Table II, based on the last report mentioned above (18), presents the ASAP areas in order of intensity of alcohol-related enforcement programs. They were divided into four groups; (a) those in which at least one arrest is made for every 28 to 36 licensed drivers; (b) those in which arrests are made at the rate of one in every 36 to 50 licensed drivers; (c) those in which one arrest is made in every 53 to 100 licensed drivers, and (d) those among whom the rate of arrests varied from one in every 111 to one in every 200 drivers.

TABLE II *Distribution of ASAP areas by number of arrests per 1000 licensed drivers and number of fatal nighttime crashes in baseline year and operational year with change in per cent*

Areas	Per cent Increase in arrests	Arrests per 1000 Drivers	Night Fatal Crashes Baseline Year	Night Fatal Crashes Operational Year	Per cent Change
Group A – *Making one arrest for every 28 to 36 licensed drivers*					
Albuquerque, N.M.	273	31	34	54	+59
Columbus, Ga.	135	35	9	11	+22
Pulaski Co., Ark.	517	32	19	16	–16
			62	81	+30.6
Group B – *Making one arrest for every 36 to 50 licensed drivers*					
Indianapolis, Ind.	287	23	29	19	–34
Kansas City, Mo.	125	20	46	35	–24
Oklahoma City, Okla.	196	23	30	38	+26
Richland Co., S.C.	108	22	23	18	–22
San Antonio, Tex.	347	24	47	70	+46
Tampa, Fla.	465	28	58	88	+52
			233	268	+15.0
Group C – *Making one arrest for every 53 to 100 licensed drivers*					
Charlotte, N.C.	110	18	37	29	–21
Denver, Col.	144	10	60	56	–7
Portland, Ore.	171	13	31	36	+16
Seattle, Wash.	112	14	94	59	–37
Fairfax Co., Va.	4910	14	39	31	–21
Hennepin Co., Minn.	117	14	42	46	+10
Lincoln, Neb.	336	17	6	2	–67
Maine	62	13	33	12	–55
New Hampshire	201	17	78	61	–28
New Orleans, La.	198	18	47	33	–30
Phoenix, Ariz.	31	19	46	45	–2
			513	410	–20.1
Group D – *Making one arrest for every 111 to 200 drivers*					
Nassau Co., N.Y.	101	5	79	73	–8
Washtenau Co., Mich.	80	9	31	24	–23
Wisconsin	205	8	22	18	–18
Baltimore, Md.	79	6	70	56	–20
Boston, Mass.	95	5	48	32	–33
Cincinnati, O.	691	7	39	37	–5
South Dakota	79	7	91	97	+7
Vermont	216	8	16	21	+31
Wichita, Kan.	135	7	24	28	+17
			420	386	–8.1

Source: Figure 11 (Evaluation of Operations 1973) of Reference (18).

Again it can be seen that the expected did not happen; those with the highest enforcement rate showed a 31 per cent increase in nighttime fatal crashes; the next highest group showed an increase of 15 per cent in nighttime fatal crashes; the next lower group had the best record regarding nighttime fatal crashes with a reduction of 20 per cent. The group with the lowest enforcement rate showed a decline of 8 per cent in the number of nighttime fatal crashes. The authors of the official evaluation report were correct; there is no evidence of a relationship between alcohol-related arrest activity and the change in level in nighttime fatal crashes.

In view of this finding, another statement in the same report is questioned. It is recommended that "significant increase in the level of arrests seem in order for some ASAPs. Arrest rates below 2 per cent of licensed drivers are not likely to produce any significant deterrence of driving while intoxicated or identify even a nominal number of the problem drinkers for possible help by ASAP treatment programs." (18, p. 22) Tables I and II in the present paper based on these reports show that this recommendation is based more on popular logic than on scientific evidence. The 'improvement' was found, not among those communities in which 2 per cent or more of all licensed drivers were arrested, but among those in which the arrest rate was below 2 per cent. Among the nine communities with arrest rates of 2 per cent or more, the number of nighttime fatal crashes deteriorated from an average of 295 in the baseline years to 349 such crashes during the operational years.

This brings us to a more revealing statement in the earlier evaluation (17):

> *The question has never been answered as to how many arrests would have to be made and publicized to optimally create a high enough perception of risk of being apprehended to deter most potential drinking drivers from violating the DUI laws. This is the goal to which enforcement should be directing itself.* (p.2)

The candor of the above statement is to commended, but the reasoning is questioned. Overall, in the 29 ASAP communities, arrests are already being made at the average rate of one for every 72 licensed drivers, and among the 7 communities in which such arrests are being made at the rate of one in every 28 to 50 drivers (3.1 to 3.5 per cent of all licensed drivers), there has been a general increase in the number of nighttime fatal crashes. However, it is still the goal to increase the number of arrests. Under the circumstances described above, the logic for placing "the highest priority on increasing the arrest rate" must be questioned; there is no evidence that such increased arrests will prevent traffic deaths.

The present author is inclined to accept as more prudent another statement in this report:

> *A remaining analytic task is to relate the profiles of drivers arrested to those fatally injured and to those both successful and unsuccessful in rehabilitation programs. This is an extremely important task since it may be that the type of person arrested is not the type of person heavily involved in fatal crashes.* (17)

With this the present author concurs. The evidence suggests that more emphasis should be placed on the dissimilarities between drivers convicted of DWI and those who are killed with high BACs rather than on the similarities. Continued emphasis on the similarities between those groups will only serve to encourage the continuation of present policies. Emphasis on dissimilarities may provide clues as to why the present system is not working.

SUMMARY AND CONCLUSION

A review of the literature reveals that (a) the role of alcohol as a causal factor in fatal crashes is poorly defined; (b) the level at which alcohol becomes a statistically significant factor in fatal crashes has not been determined; (c) present beliefs about drinking-driving crashes and programs to alleviate the problem are based on incomplete and biased data; and (d) the proportion of all traffic deaths in the United States that may be related to alcohol in some causal fashion is closer to 30 per cent than to 50 per cent.

This is important because (a) if the figure is 30 per cent rather than 50 per cent, there are approximately 70 per cent of all fatal crashes to which we are paying very little attention; and (b), if the problem were more correctly defined, the likelihood of designing effective countermeasures and subsequent ability to measure progress would be enhanced.

There is evidence that (a) fatal crashes are different from run-of-the-mill collisions; (b) that drivers in fatal crashes are different from drivers in run-of-the-mill collisions; and (c), that different countermeasures may be needed for fatal crashes than for collisions-in-general.

Although alcoholics and youth represent special problems, it is only among a minority of those groups that the problem is concentrated.

It is suggested that those who are killed while drunk are different in significant ways from those convicted of DWI. There is a need to study the differences rather than the similarities between those killed and those arrested. This procedure may provide the clues necessary to make the system more effective.

Mass arrests for DWI, even to the extent of arresting more than 3 per cent of the licensed population, have proven ineffective.

Traditionally, it has been assumed that all drivers who drink heavily are equally dangerous and it is on this premise that enforcement programs are applied against all drinking drivers. Research indicates, however, that not all drinkers are equally dangerous when driving and that it is not alcohol alone that leads to crash involvement, but alcohol in combination with other factors or characteristics. This, together with the finding that 70 per cent or more of all fatal crashes are not related to alcohol in any causal fashion, suggests the need to identify a larger group of high-risk drivers whose deviant behavior leads to crash involvement with or without alcohol and among whom some use alcohol as a triggering device. Broadened emphasis on a larger group of high risk drivers should result in the identification of several categories of such drivers among whom one or more use alcohol to excess or to trigger violent behavior. In other words, *rather than the high-risk alcohol abusers being a sub-group of all drivers, the alcohol abusers who are involved in violent crashes should be considered a sub-group of a much larger population of high-risk drivers.*

This new perspective of the fatal crash problem should not only aid in the identification of high risk drinking drivers but also the high risk non-drinking drivers. In this way we could combat the 70 per cent of all traffic deaths not related to alcohol as well as the 30 per cent that may be related to alcohol in some causal fashion.

Real progress can be expected only after the problem is more clearly defined and countermeasures specifically applied.

REFERENCES

1. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., and Zylman, R., The Role of the Drinking Driver in Traffic Accidents (The Grand Rapids Study) *Blutalkohol*, Vol. 11, (Supplement 1) 1974.
2. Brenner, B. and Selzer, M. L., Risk of Causing a Fatal Accident Associated with Alcoholism, Psychopathology and Stress: further analysis of previous data. *Behavioral Science* 14, 490-495 (1969).
3. Brown, E. W., The Killer Drunk: now we can Slow his Slaughter. *The Saturday Evening Post*, Fall, 1971. Pages 65-67, 148-149, 151.
4. Brown, S. L. et al, *Drivers who Die: Alcohol Safety Study*. DOT NHSB Contract No. FH-11-6603, Baylor University College of Medicine, Houston, Texas, 1968.
5. Clay, M. L., *Which Drunks shall we Dodge? Selected Papers,* Twenty-third Annual Meeting, Alcohol and Drug Problems Association of North America, Atlanta, Georgia, September 10-15, 1972. p. 42-46.
6. Filkins, L. D., Clark, C. D., Rosenblatt, C. A., Carlson, W. L., Kerlan, M. W. and Manson, H., *Alcohol Abuse and Traffic Safety: a Study of Fatalities, DWI Offenders and Alcoholics and Court-Related Treatment Approaches.* (DOT NHTSA contract FH-11-6555 and FH-11-7129), Ann Arbor, Michigan; Highway Safety Research Institute, University of Michigan, 1970.
7. Lawlis, G. F. and Rubin, S. W., 16-PF study of Personality Patterns in Alcoholics. *Quarterly Journal of Studies on Alcohol* 32, 318-327, (1971).
8. Pelz. D. C. and Schuman, S. H., *Drinking, Hostility and Alienation in Driving of Young Men.* Presented to Third Annual Alcoholism Conference, NIAAA, Washington, D.C., June 1973.
9. Pelz, D. C., McDole, T. L. and Schuman, S. H., Drinking-driving Behavior of Young Men in Relation to Accidents. *Quarterly Journal of Studies on Alcohol* (in press).
10. Perrine, M. W., Waller, J. A. and Harris, L. S., *Alcohol and Highway Safety: Behavioral and Medical Aspects* (Project ABETS, DOT NHTSA Contracts No. FH-11-6609 and FH-11-6899. Final Report, Project 14) Burlington: University of Vermont, 1971.
11. Schmidt, W. S. and Smart, R. G., Alcoholics, Drinking and Traffic Accidents. *Quarterly Journal of Studies on Alcohol* 20, 631-644, (1959).
12. Selzer, M. L., Payne, C. E., Gifford, J. D. and Kelly, W. L., Alcoholism, Mental Illness and the Drunk Driver". *Municipal Court Review* 3 (No. 3): 1963. pp. 9-14.
13. Selzer, M. L., Rogers, J. E. and Kern, S., Fatal Accidents: the Role of Psychopathology, Social Stress and Acute Disturbance. *American Journal of Psychiatry* 124, 1028-1036 (1968).
14. Selzer, M. L. and Chapman, M., Differential Risk among Alcoholic Drivers. *Fourteenth Annual Conference of the American Association for Automotive Medicine*, Ann Arbor, Michigan, Highway Safety Research Institute, The University of Michigan, 1971. Pp 207-213.
15. Thomas, J. M. and Chang, K. H., Comparison of Drinking Fatality Population and a Convicted Drunk Driver Sample. In *Drinking Driver and Traffic Safety Project, Annual Report, July 1970*, Pollack, S. Principal Investigator, DOT NHSB Contract No. FH-11-7099, Public Systems Research Institute, University of Southern California, 1970.
16. U.S. Congress, House Committee on Public Works, Subcommittee on Roads, Federal-Aid Highway and Highway Safety Programs. *Hearings on H.R. 9446, 91st Congress, 1st Session* May 21, June 4-5, 1969, Washington, 1969 (Brenner, pp 499-523).
17. U.S. Department of Transportation, National Highway Traffic Safety Administration, Office of Alcohol Countermeasures. *Alcohol Safety Action Projects; Evaluation of Operations, 1972.* Vol. II, detailed analysis, Chapter 2, ASAP program evaluation methodology and overall program impact. DOT HS 800 874, Washington, D.C.
18. U.S. Department of Transportation, National Highway Traffic Safety Administration, Office of Alcohol Countermeasures, *Alcohol Safety Action Projects: Evaluation of Operations-1973*, preliminary evaluation of first two years operations for 29 projects funded in FY 1970 and 1971, April, 1974, DOT HS 800 973, Washington, D.C.
19. Waller, J. A., Drinking Drivers and Driving Drinkers: the Need for Multiple Approaches to Accidents Involving Alcohol. In *Prevention of Highway Injury*, Selzer, M. L., Gikas, P. W. and Huelke, D. F., (eds.) Highway Safety Research Institute, The University of Michigan, Ann Arbor, 1967.

20. Zador, P., *Statistical Evaluation of the Effectiveness of "Alcohol Safety Action Programs."* Insurance Institute of Highway Safety, Watergate 600, Washington, D.C., 1974.

21. Zelhart, P. F., Types of Alcoholics and their Relationship to Traffic Violations. *Quarterly Journal of Studies on Alcohol* 33, 811-813, (1972).

22. Zylman, R. The Variability of Collision Involvement at Low Blood Alcohol Concentration: the Grand Rapids Curve Explained. *Blutalkohol* 9, No. 1, Jan. 1972.

23. Zylman, R., Youth, Alcohol and Collision Involvement. *Journal of Safety Research* 5, 58-72 (1973).

24. Zylman, R., Overemphasis on Alcohol may be Costing Lives. *Police Chief* 41, 64-67 (1974).

25. Zylman, R., A Critical Evaluation of the Literature on "Alcohol-Involvement" in Highway Deaths. *Accident Analysis and Prevention* (in press).

26. Zylman, R., Blood Alcohol Limits and the Incidence of Traffic Fatalities: a critical review. *Quarterly Journal of Studies on Alcohol* (in press).

Identification of the Drinking Driver

Alexander Kornaczewski[1]

A review of the literature on drinking drivers (3) shows that alcohol impairs skills required in driving, and results in increased risk of involvement in accidents, especially those of a serious nature. The risk increases with increasing blood alcohol concentrations (BACs).

While many persons drink and drive at least occasionally, the BACs of drivers arrested on drink-driving charges or involved in accidents indicate that it is the excessive drinker, representing a small proportion of the driving population, who poses the proportionately greatest menace on the roads.

Alcoholics and potential alcoholics, that is, problem drinkers who have lost control of their drinking, have been shown to be over-represented among these excessive drinkers (2, 4). At present alcoholics who come to clinics for treatment are usually over forty years of age. This results from physical complications which arise after an average of 15 to 20 years of excessive drinking. Earlier recognition of alcoholism would result in a better chance of rehabilitation and would enable the person to receive symptomatic treatment for physical complications before they become irreversible. Motor car accidents and drink-driving charges seem to be some of the first signs to medical and legal authorities of a potential alcoholic.

Drivers who are problem drinkers are immune to the normal process of education because drinking is so ingrained in their life style. Therefore there is an urgent need to detect and treat problem drinkers if their role in accidents is to be minimized. Information on the characteristics of the drinking driver could be used to develop screening devices for their detection and the early identification of alcoholism.

This paper presents part of a study (3) undertaken with the primary intention of identifying the drinking driver by his pattern of traffic convictions. The study was carried out in Victoria, Australia in 1969 under the auspices of the Alcoholism Clinic at St. Vincent's Hospital in Melbourne.

Data for the study consisted of the driving and criminal records of three groups of drivers in the state of Victoria. These were:

a) A control group consisting of a random sample of 649 Victorian drivers.

b) An alcoholic group consisting of 434 persons who had voluntarily attended the Alcoholism Clinic at St. Vincent's Hospital for treatment in the years 1964 to 1969. They came from all socio-economic strata, were referred by a variety of medical and non-medical agencies, and fell within the definition of alcoholism propounded by the World Health Organization in 1952 (6, 8).

---

[1] Addiction Research Foundation, 33 Russell St., Toronto, Ontario M5S 2S1, Canada.

c) A group of 458 breathalized drivers consisting of a one in five sample of persons coming to police attention and subsequently interviewed by the Police Breath-analysis Squad in 1967.

Each of these groups had been refined so as to be restricted to males who had held a Victorian driving licence during the previous 16 years. Women were excluded because of the small number of convictions. Comparisons between groups were often restricted to those between drivers from the metropolitan area in order to make more accurate comparisons, as there were varying proportions of drivers from areas other than the metropolitan in the three groups.

In comparison to the other two groups, only a limited analysis was made of the breathalized group because breathalized drivers invariably had at least one conviction which arose from the behaviour that brought them into the sample. Removal of this offence presented practical as well as interpretative difficulties and was therefore not attempted.

Driving convictions for the three groups were examined in general and then for particular offences. Association between offences, and also similarities and differences in offences between groups, were noted and the criminal records were studied in the light of these observations.

In Table I the proportions of drivers convicted of traffic offences are given for each group. After adjustments were made for age differences it was found that alcoholics were 1.7 times as likely as controls to have convictions. Even when all convictions were considered the differences between the three groups were not large. The average number of convictions per convicted driver adjusted for age differences was 2.0 for controls, 2.3 for alcoholics and 2.7 for breathalized drivers. One noticeable difference in general convictions between the three groups lay in the pattern of convictions for the first ten years of licensing. For controls, the average number of convictions per year decreased with the length of time a licence had been held. This pattern did not hold for breathalized drivers, nor did it seem to hold for alcoholics.

TABLE I *Number of metropolitan male licence holders with convictions*

Group	Number convicted	Number at risk
Control	147 (34%)	429
Alcoholic	201 (55%)	364
Breathalyzed	393 (97%)	406

Differences between the groups became more apparent with the analysis of the offences behind the numbers of convictions. The pattern of offences of the control group was first examined separately so as to gain some perspective of the incidence of various offences (Table II).

The category ‘Driving faults’ included such offences as failing to give way, failing to obey signs and signals, failing to give signals and crossing double lines. Combined in the category ‘Serious offences’ were offences relating to:

a. accidents (*i.e.* failing to stop after an accident)
b. driving manner (*i.e.* dangerous or careless driving)
c. unlicensed driving, and
d. illegal use (*i.e.* unauthorized use of a motor vehicle)

The category 'Drink-driving' included the offences:

a. driving under the influence of intoxicating liquor
b. being drunk in charge of a vehicle, and
c. driving with a BAC exceeding 0.05 g/100 ml.

Speeding, which was the most common offence, was committed by 27% of male drivers from the metropolitan area. The offence of speeding was often repeated, and 40% of those convicted had repeated convictions. Few drivers were convicted of drink-driving offences or serious offences. There was a small proportion of drivers (2.8%) convicted of drink-driving offences. However, a large proportion of these repeated their offences, that is when all male licence holders were considered it was found that 4 out of 17 drink-driving offenders (23%) had repeated convictions. This suggests that there is a small segment of the population who are particularly prone to this type of offence probably because they habitually drink and drive.

TABLE II *Types of offences committed by the control group of male metropolitan licence holders*

Type of offence		Number convicted		Percentage convicted
Speed		114		26.6
Driving faults		47		11.0
Car faults		18		4.2
Accident	Serious offences	4	12[a]	2.8
Driving manner		7		
Unlicensed driving		5		
Illegal use		1		
Drink-driving		12		2.8
Total number convicted[b]		147		34.3
Number at risk		429		

[a] Twelve drivers received 16 serious offence convictions.
[b] Some drivers appeared in more than one category of serious offences.

Most categories of serious offences contained persons who had also been convicted of drink-driving offences (Table III), although persons committing serious offences tended to be younger than drink-driving offenders. A total of 4 out of 22 males convicted of these offences (18%) had drink-driving convictions. This was in contrast to the small proportion of speed offenders (3%) who had drink-driving convictions. This overlap of persons committing serious offences and those committing drink-driving offences suggests that alcohol may have been an unrecognized factor in some other serious offence cases or at least be part of the life style of the offenders.

From another perspective, 7 out of 17 drink-driving offenders had other convictions – either for further drink-driving offences or for serious offences. This high repetition rate together with a generally high proportion of offences of this nature among all their offences reinforces the impression that those drink-driving offenders who are caught often drive while intoxicated.

TABLE III *The incidence of drink-driving convictions among male licence holders from the control group convicted of other serious offences or speeding*

Type of offence	Number convicted	Number with drink-driving convictions
Dangerous manner	10	2
Accident	5	1
Unlicensed driving	6	1
Illegal use	2	0
All serious offences	22[a]	4 (18%)
Speeding	147	5 (3.4%)

[a] One person was convicted of unlicensed driving and illegal use on separate occasions and therefore the total number of convictions is one more than the total number of people convicted for all serious offences.

In Table IV is shown the occurrence of various offences among the alcoholics. With more drivers having convictions and more convictions per driver than controls there was an increased likelihood of drivers appearing in more than one offence category. Speeding was again the most common offence with 26% of drivers being convicted of this offence. Drink-driving convictions were also fairly common (21% of drivers).

When the association of persons involved in serious offences and drink-driving offences were investigated for alcoholics, an overlap averaging 31% was found (Table V). This was greater than that for controls as we would expect from the nature of the group being considered. It should be noted however that this overlap was much greater than that between speed offenders and drink-driving offenders.

Alternatively a substantial proportion of alcoholics with drink-driving convictions (31%) also had convictions for serious offences. This proportion was greater than the proportion of alcoholics with drink-driving convictions who also had speed convictions although speeding was the more common offence.

The offence patterns of controls and alcoholics are compared in Table VI. The alcoholic's risk of conviction for various offences is based on a risk of one for controls. The only similarity between the two groups was in the likelihood of speed convictions. Even then the speed offences of the alcoholic were more likely to be of a serious nature, and his other offences were less likely to consist only of speed offences. The alcoholic driver was significantly more likely to be convicted of offences relating to drink-driving, driving manner, accidents, unlicensed driving and illegal use. These differences remained even when only convicted drivers in each group were compared.

TABLE IV *Types of offences committed by metropolitan male licence holders from the alcoholic group*

Types of offence		Number convicted		Percentage convicted
Speed		93		25.5
Driving faults		57		15.6
Car faults		24		6.6
Accident	Serious offences	38	82[a]	22.5
Driving manner		53		
Unlicensed driving		26		
Illegal use		11		
Drink-driving		76		20.9
Number convicted		201[b]		55.2
Number at risk		364		

[a] Eighty-two drivers received 128 serious offence convictions.
[b] Some drivers appeared in more than one category of serious offences.

TABLE V *The relationship between serious and drink-driving offences for the alcoholic group of male licence holders*

Type of Offence	Serious Offenders			
	Number convicted	With drink-driving convictions N	With drink-driving convictions %	Percentage of Drink-Driving Offenders with serious offences
Dangerous manner	51	15	29	17
Accident	26	8	31	9
Unlicensed driving	23	12	52	13
Illegal Use	8	3	37	3
All serious offences[a]	89	28	31	31
Speeding	103	19	18	21

[a] Some drivers appeared in more than one category of serious offences.

TABLE VI *The relative risk[a] of conviction for different offences for the alcoholic group of metropolitan male licence holders*

	Risk	
Type of Offence	Unadjusted	Adjusted for Date of Birth
Drink-driving	7.3	7.5
Dangerous manner	8.7	9.5
Accident	10.9	11.9
Unlicensed driving	6.0	9.8
Illegal use	12.7	19.7
Serious/Drink-driving	6.4	7.1
Speed	0.9	1.2
Speed only	0.5	0.7
Any offence	1.6	1.7

[a] Based on a risk of 1 for controls for each type of offence.

Although similar results as far as the relative frequency of drink-driving offences among alcoholics have been obtained in several other studies (2, 6), the only known comparable study of offences was carried out by Crancer and Quiring (1) in King County, Washington, in 1969. They compared the offences over a six-year period of 140 alcoholics of average age 50 years with the general population in the same county matched for age and sex. They also found that alcoholics were more likely to be involved in offences relating to drink-driving, driving manner, accidents and unlicensed driving. Their finding for speed offences differs from that of the present study as also does the extent of the differences between the two groups for other offences. This is probably the result of a different method of analysis. Crancer and Quiring worked in terms of the frequency of various offences among all the offences committed by a particular group, whereas in the present study the analysis has been in the form of the frequency of various offences among all the drivers in a particular group.

The nature of the sample of breathalized drivers prevented a direct comparison with controls in terms of their patterns of offences. Most of the breathalized drivers were drink-driving offenders and a comparison between groups of these drivers was possible. The proportion of drink-driving offenders in the three groups with repeated drink-driving offences was 23% for controls, 22% for alcoholics and 20% for breathalized drivers. The proportion of drink-driving offenders with convictions for serious offences or further drink-driving offences was 41% for controls, 42% for alcoholics and 39% for breathalized drivers.

Table VII shows the involvement in serious offences of the drink-driving offender in the breathalized group. This involvement in comparison with that of the alcoholic drink-driving offender in serious offences (Table V) was on a similar but slightly lower level. The only large differences occurred for unlicensed driving. The similarities between the alcoholic drink-driving offender and drink-driving offenders again suggest that drinking drivers are, like alcoholics, over-represented among serious offenders.

TABLE VII *The incidence of convictions for serious offences among male licence holders from the breathalyzed group convicted of drink-driving offences*

Type of offence	Number convicted	Percentage convicted
Dangerous manner	64	15.8
Accident	27	6.6
Unlicensed driving	32	7.9
Illegal use	9	2.2
All serious offences[a]	104	25.6
Drink-driving	406	100.0

[a] Some drivers appeared in more than one category of serious offences.

An examination of the available BACs associated with drink-driving convictions (Table VIII) showed that alcoholics had a significantly higher proportion of drivers with BACs over 0.20 g/100 ml. This was true for all age groups. About half the BACs recorded for breathalized drivers aged between 25 and 50 years were over 0.20 g/100 ml, whereas all those for alcoholics from a similar group were above this level. This suggests that problem drinking and alcoholism are best detected by the investigation of drivers with high BACs. The lower limit of detection of these drivers should however be low enough to detect young problem drinkers.

TABLE VIII *The blood alcohol concentrations of male licence holders from the alcoholic and breathalyzed groups of drink-driving offenders*

	Blood Alcohol Concentration (g/100 ml)				
	<.10	.10–.14	.15–.19	.20–.24	⩾.25
Number of Alcoholics	0	2	2	17	18
Number of Breathalyzed Drivers	26	84	148	93	56

Table IX shows the types of criminal records (excluding driving charges) among the three groups of drivers. For each group the likelihood of a criminal record increased with the seriousness of any traffic convictions incurred by the driver. In each conviction category the alcoholics had the highest proportion of drivers with criminal records.

TABLE IX *Criminal records of metropolitan male licence holders*[a]

Type of Traffic Conviction	Percentage Convicted			Number at Risk		
	Controls	Alcoholics	Breath-alyzed	Controls	Alcoholics	Breath-alyzed
Drink-driving	33	50	41	12	76	361
Serious	17	45	46	12	58	13
Other convictions	15	37	11	123	67	18
Any convictions	17	44	40	147	201	393
No convictions	8	28	25	282	163	12
TOTAL	11	37	40	429	364	405

[a] Excluding any driving charges.

To summarize, the study showed that alcoholics have a distinctive pattern of offences. They were significantly more likely than controls to be convicted of offences relating to drink-driving, dangerous driving, accidents, unlicensed driving and illegal use of motor vehicles. This pattern of offences extended to convicted drinking drivers and suggested that alcohol was an unrecognized factor in more serious offences. The repetition of drink-driving and serious offences (which were relatively uncommon) and the frequent high BACs of the drivers involved indicated that many of these drivers often drove while intoxicated. The determination of the BACs of the persons involved in these offences together with this pattern of offences should be used as a screening device to identify problem drinkers for subsequent treatment. Licence withdrawal was shown to be an ineffective answer because of the continued convictions of these drivers.

The criminal records helped indicate that while alcohol was a factor in traffic offences there were other factors involved as shown by the different number of records among the alcoholics. The correlation between types of traffic convictions and criminal records, and the similarity of the types of offences among a driver's convictions, suggested that many drivers frequently drive or act in that manner. A similar conclusion was reached by Willett (7), namely, that a person drives as he lives. This needs to be taken into account by authorities dealing with prevention measures.

REFERENCES

1. Crancer, A. and Quiring, D. L., The Chronic Alcoholic as a Motor Vehicle Operator, *Northwest Medicine* 68, 42 (1969).

2. Goldberg, L., Drunken Drivers in Sweden. In *Proceedings of the 2nd International Conference on Alcohol and Road Traffic*, p. 112, 1955.
3. Kornaczewski, A., *The Drinking Driver*, M.Sc. Thesis, University of Melbourne, 1971.
4. Popham, R. E., Alcohol and Traffic Accidents, *Quarterly Journal of Studies on Alcohol* 17, 225 (1956).
5. Schmidt, W. S. and Smart, R. G., Alcoholics, Drinking and Traffic Accidents, *Quarterly Journal of Studies on Alcohol* 20, 631 (1959).
6. Wilkinson, P., Kornaczewski, A., Rankin, J. G. and Santamaria, J. N., Physical Disease in Alcoholism. Initial Survey of 1,000 Patients, *Medical Journal of Australia* 1, 1217, (1971).
7. Willett, T. C., *Criminal on the Road: A Study of Serious Motoring Offences and Those Who Commit Them*. Tavistock, London, England, 1964.
8. World Health Organization Expert Committee on Mental Health, Alcohol Subcommittee Second Report, *World Health Organization Technical Report Series, No. 48* (1952).

The Importance of Psychosocial Factors on Drinking in Alcoholics: Relevance for Traffic Safety

John S. Tamerin [1]

One clear finding has emerged from the research to date on traffic accidents: in at least half of all cases of serious injuries or fatalities, alcohol is a major etiologic factor (9). Research on drivers involved in traffic accidents where alcohol has been implicated has most often concentrated on blood alcohol levels (12). The association between automobile accidents and psychological variables, particularly pre-existing personality patterns, has also been investigated, (7, 11). Other research has examined the relationship of situational variables such as time of day (10). With the exception of Selzer's work (5, 6), few studies of accidents involving alcohol have looked at both psychological and social-situational determinants. Research at the Silver Hill Foundation suggests that this line of investigation should be pursued.

In our research, we have examined the contribution made by various psychosocial factors to the act of drinking by alcoholics. To this end, we have conceptualized alcoholic drinking as a complex process usually involving the following components: (a) situational stress, (b) arousal of an affect, (c) activation of a desire to drink, and (d) the act of drinking itself.

This study focuses on the interrelationships of these four components of the drinking process in a group of male and female alcoholic inpatients. The psychodynamic implications of the findings and their relevance to traffic safety will also be discussed.

METHOD

The subjects studied were 50 alcoholic inpatients (25 men, 25 women) at the Silver Hill Foundation, a private psychiatric hospital in New Canaan, Connecticut. All had entered the hospital voluntarily, although in many cases they had come under pressure from a spouse or employer. The ages of the patients ranged from 30 to 71 years, with a median age of 51. Their history of problem drinking ranged from two to 30 years, with a median of nine years. Educationally, the sample ranged from high school to postgraduate training; the majority of subjects were college graduates. Socio-economic distribution was primarily middle, upper-middle, and upper class.

The subjects were part of a larger patient population whose perceptions of their

---

[1] Director of Research, Silver Hill Foundation, New Canaan, Connecticut, 06840, U.S.A.

own drinking problems, as assessed by the Michigan Alcoholism Screening Test, revealed that: 100 per cent felt that they were not normal drinkers; 96 per cent reported that they "felt bad" about their drinking; 83 per cent reported blackouts; 82 per cent acknowledged that drinking had created problems in their marriage; 54 per cent had been previously treated in a hospital because of an alcohol-related illness; 52 per cent acknowledged severe withdrawal symptoms following cessation of drinking; 48 per cent were aware of liver damage as a result of excessive drinking; and 16 per cent reported having been arrested for drunken driving.

Procedure

A self-report questionnaire, based on Hershenson's instrument (3), describing 15 situations perceived by alcoholics as particularly stressful, was administered to all subjects. These 15 situations were divided equally among three areas or systems, *i.e.*, five were specific to the self, five to interpersonal relations, and five to work. These three areas have been conceptualized by Erikson (1, 2) as central to the individual's sense of identity. The situations as they appeared on the form are shown in Table I.

TABLE I *Fifteen Situations Perceived as Stressful by Alcoholics*

1. When you are about to begin a day's work.
2. When you are asked to do work which may be beyond your capabilities.
3. When you have an argument with someone close to you.
4. When you are asked to do something you consider to be beneath you.
5. When someone lets you down.
6. When you are alone and have nothing to do.
7. When you make a mistake.
8. When someone criticizes you.
9. When a personal problem seems to be more than you can handle.
10. When the quality of your work has been questioned.
11. When you can't make a decision.
12. When you are forced to work under pressure.
13. When you think of what you have done with your life.
14. When you are forced to be with someone you don't like.
15. When you are asked to speak in front of a group.

The questionnaire lists 12 adjectives after each potentially stressful situation. Each adjective denotes one of three intensity levels (low, moderate, or high) of four affective states (anger, anxiety, depression, or positive affect). The adjectives reflecting the three intensity levels for the three negative affect states are presented in Table II.

TABLE II *Adjectives Reflecting Three Intensity Levels for the Three Negative Affect States*

Intensities	Affect States		
	Anxiety	Anger	Depression
Low	Uneasy	Annoyed	Blue
Moderate	Anxious	Angry	Depressed
High	Panicky	Furious	Hopeless

Subjects were first asked to indicate which one of the 12 adjectives best described how they felt in each of the 15 potentially stressful situations. They were next requested to review the 15 situations again and to indicate which had been associated with a desire to drink during the past year. The 15 situations were then presented a third time, and the subjects were asked to identify which situations had resulted in actual drinking during the same time interval.

RESULTS

Desire to Drink and Actual Drinking

The patients reported that, regardless of the situation or the affect aroused, once the desire to drink occurred, actual drinking almost always followed. Actual drinking accompanied the desire to drink 93 per cent of the time. Regardless of the affect aroused, the association of desire to drink and actual drinking was extremely high. However, this relationship did differ significantly among affective states ($X^2 = 8.30$, $p < .05$). For example, when depression was activated under stress, drinking followed the desire to drink in 100 per cent of situations, whereas when anger was aroused, the desire to drink led to drinking in 88 per cent of instances.

Affect and Desire to Drink

The desire to drink varied with the affect aroused ($X^2 = 16.66$, $p < .001$) as can be seen in Table III.

TABLE III *Frequency With Which Each Negative Affect State Is Associated With Desire to Drink*

Affect	Patients		
	Males %	Females %	Males and Females %
Depression	63	67	66
Anxiety	41	62	51
Anger	41	46	43

Specifically, when depression was reported in response to a stressful situation, there was a desire to drink 66 per cent of the time; when anxiety was reported, desire to drink occurred 51 per cent of the time; when anger was reported, desire to drink occurred 43 per cent of the time. In comparing men with women on the relationship between affect and desire to drink, when anxiety was reported, women more often than men (62 per cent compared to 41 per cent) acknowledged a desire to drink ($X^2 = 11.00$, $p < .001$). As for the relationship between affect intensity and the desire to drink, it was found that high intensity levels of reported affect were no more likely to be associated with desire to drink than moderate or low intensity levels for any of the three negative affect states.

System, Situation, and Desire to Drink

Stressful situations classified as belonging to either the self system or to the interpersonal system were associated with desire to drink at least 50 per cent of the time for the group as a whole. In contrast, stressful situations in the work system were less frequently associated with desire to drink ($X^2 = 36.42$, $p < .001$). Table IV shows the frequency with which various systems were associated with the desire to drink for each sex and for the combined sample.

TABLE IV *Frequency With Which Each System (Self, Interpersonal, Work) Is Associated With Desire To Drink*

System	Patients		
	Males	Females	Males and Females
	%	%	%
Self	46	62	54
Interpersonal	40	60	50
Work	26	32	29

Analysis of individual stressful situations, without regard to system, revealed that three of the 15 situations were reported by these 50 patients to be associated with the desire to drink more frequently than the other 12, as is shown in Table V.

The situation "When you are alone and have nothing to do" was associated with the desire to drink in 76 per cent of cases for the total population. The situations "When a personal problem seems to be more than you can handle," and "When you have an argument with someone close to you," were reported to be related to the desire to drink in 74 per cent of instances. At the other extreme, four of the situations reported to be least frequently associated with the desire to drink were: "When you make a mistake," "When the quality of your work has been questioned," "When you are asked to do work which may be beyond your capabilities," and "When you are asked to do something you consider to be beneath you." Each of these situations was associated with the desire to drink less than 30 per cent of the time.

Situational Stress and Emotional Arousal

The effects of situational stress on emotional response, irrespective of whether these circumstances were associated with desire to drink, were also examined.

Table VI reveals that male patients were much less likely to report depression than they were to report either anxiety or anger in response to stress ($X^2 = 44.29$, $p < .001$). There were no differences in the frequency with which anxiety or anger was acknowledged by men. Female patients, on the other hand, reported more anxiety than anger or depression in response to stress ($X^2 = 8.80$, $p < .01$). There were no differences in the frequency with which anger or depression were reported by female patients.

TABLE V *Per Cent of Subjects Reporting a Desire to Drink in Each Situation*

Situation	Patients		
	Males %	Females %	Males and Females %
When you are alone and have nothing to do.	76	76	76
When you have an argument with someone close to you.	64	84	74
When a personal problem seems to be more than you can handle.	60	88	74
When someone criticizes you.	36	68	52
When you think of what you have done with your life.	40	56	48
When someone lets you down.	28	60	44
When you can't make a decision.	40	48	44
When you are forced to work under pressure.	32	48	40
When you are forced to be with someone you don't like.	40	40	40
When you are asked to speak in front of a group.	32	48	40
When you are about to begin a day's work.	32	36	34
When you make a mistake.	12	40	26
When the quality of your work has been questioned.	24	28	26
When you are asked to do work which may be beyond your capabilities.	12	36	24
When you are asked to do something you consider to be beneath you.	12	36	24

TABLE VI *Frequency With Which Each Affect State (Negative and Positive) Occurs in Response to Stress*

Affect	Patients	
	Males %	Females %
Anxiety	33	33
Anger	31	23
Depression	11	22
Positive Affect	25	22

In comparing male and female patients, the women were more likely to report depression in response to stress than were the men ($X^2 = 15.46$, $p < .01$). This difference was particularly evident in the interpersonal sphere, which included such situations as: "When you have an argument with someone close to you," "When someone lets you down," and "When someone criticizes you." Male patients, in contrast, were more likely to report anger in response to stress than were the female patients ($X^2 = 7.45$, $p < .01$).

DISCUSSION

The extremely strong association between desire to drink and actual drinking reported by these 50 patients indicates that, for the alcoholics in this study, the desire to drink was tantamount to drinking, regardless of the precipitating context or the affect aroused. There was essentially no break in the process once the desire to drink had been activated. The desire to drink, however, was observed to be differentially related to the affect aroused and to the context. Depression was more often associated with a desire to drink than anxiety or anger, and stress in the self or interpersonal spheres was more likely to be related to a desire to drink than stress at work.

The three situations particularly associated with desire to drink were: "When you are alone and have nothing to do," "When a personal problem seems to be more than you can handle," and "When you have an argument with someone close to you." These are situations in which there is no specific directive available and no defined solution. Also, these situations are often clinically observed to be associated with feelings of helplessness or hopelessness. In these situations most often associated with the desire to drink and with drinking, the alcoholic often feels lost: there is nothing concrete or structured to do. There is no external direction, no guidelines or controls. These unstructured personal situations without external guidelines may bring the alcoholic into contact with his own lack of inner direction, his low self-esteem, his masochistic tendencies, and his repetitive need to hurt himself or others through the act of drinking. Under these circumstances, the alcoholic may be terrified of becoming overwhelmed by uncontrollable feelings of dysphoria, and may drink in an attempt to control or obliterate these feelings.

On the other hand, situations such as: "When you are asked to do something you consider to be beneath you," "When you are asked to do work which may be beyond your capabilities," and "When the quality of your work has been questioned" were far less frequently associated with the desire to drink. Even though the stress in these situations may be considerable, the tasks appear to be more structured and have a specific objective.

It has been our clinical observation that the focused task provides the alcoholic with a sense of purpose and thus diminishes the likelihood that he will drink. In this sense, the structure and direction of the task provide some sense of control. As a result, the alcoholic is less likely to feel hopeless and helpless. Although the situation may make the alcoholic feel disparaged – as "When the quality of (his) work has been questioned," or "When (he is) asked to do something (he) considers to be beneath (him)" – at least the guidelines are specified by the other person in the relationship, and the alcoholic can try to achieve the prescribed goal. Furthermore, in his earnest attempt to follow external guidelines, the alcoholic can temporarily avoid facing himself and his underlying feelings of worthlessness. Consequently, a seemingly unreasonable demand from someone else, as "When you are asked to do work which may be beyond your capabilities," is not nearly as painful for the alcoholic as being "alone and having nothing to do."

What are the implications of these findings to the area of alcoholism and traffic safety? First, they suggest that alcoholics do not have the same level of desire to drink in all situations, or even in all situations of stress. There are apparently certain affect states particularly conducive to drinking. Since prior research has demonstrated that the alcoholic is at greater risk to himself and others as a driver only when he is drinking (8), it becomes important to learn more about the specific circumstances most likely to be associated with drinking.

Our findings suggest that situations which are unstructured and which activate feelings of depression are most often associated with the desire to drink. Clinically, we have observed that in these situations the alcoholic feels powerless and out of control. Drinking offers a structured activity, temporary relief from dysphoric feelings, and a subjective sense of power and control. Driving, in fact, may have the same effect.

For the alcoholic, the task of driving may serve several important functions. First, it involves the driver in a complex sequence of activities which have become familiar. Second, driving provides the alcoholic with a means of escape from his feelings of dysphoria by permitting him to feel that he is placing distance between himself and his problems. Third, in the act of driving rapidly, the alcoholic may experience a singular sense of temporary exhilaration which serves as an antidote to his underlying dysphoria. Finally, driving provides a sense of control and power. As a recognized adult activity requiring a licence, the act of driving enables the individual to take command and direct a powerful and complex piece of potentially lethal machinery.

Prior psychological investigation of alcoholics who drive when intoxicated has conceptualized this act as an expression of the individual's psychopathology (4). We believe that the coping function served by the alcoholic's driving should also be considered. In attempting to understand this seemingly irrational behavior, it is useful to remember that driving, like drinking, may be one of the few activities which the alcoholic knows that he can do by himself in order to dissipate his feelings of impotence and loneliness. One of the frequently heard slogans in AA dealing with the alcoholic's insistence on maintaining control in other aspects of his life is: "Get out of the driver's seat." It is significant that the slogan chosen to highlight this rigid need to maintain control is drawn from the sphere of driving.

Recognition of this attempt at coping served by driving may help us to gain a greater understanding of why the alcoholic often refuses to relinquish the keys to his car although he may intellectually be well acquainted with the statistical risk he is taking by driving when intoxicated. Furthermore, an awareness of the psychodynamic coping function served by driving and drinking should ultimately help us to plan more effective educational and preventive programs in this area.

REFERENCES

1. Erikson, E. H., *Childhood and Society*. New York, Norton, 1950.
2. Erikson, E. H.. The Problem of Ego Identity. *Journal of the American Psychoanalytical Association* 4, 56-121 (1956).
3. Hershenson, D. B., Stress-Induced use of Alcohol by Problem Drinkers as a Function of Their Sense of Identity. *Quarterly Journal of Studies on Alcohol* 26, 213-222 (1965).
4. Selzer, M. L. et al., Automobile Accidents as an Expression of Psychopathology in an Alcoholic Population. *Quarterly Journal of Studies on Alcohol* 28, 505-516 (1967).
5. Selzer, M. L., Alcoholism, Mental Illness, and Stress in 96 Drivers Causing Fatal Accidents. *Behavioral Science* 14, 1-10 (1969).

6. Selzer, M. L. and Vinokur, A., Life Events, Subjective Stress, and Traffic Accidents. *American Journal of Psychiatry* 131, 903 (1974).
7. Shaffer, J. W. et al., Social Adjustment Profiles of Fatally Injured Drivers. *Archives of General Psychiatry,* 30, 508-511 (1974).
8. Smart, R. G. and Schmidt, W. S., Problem Drinking as a Factor in Drinking Driver Offences. *Canadian Journal of Corrections* 3, 153-158 (1968).
9. Voas, R. B., Alcohol as an Underlying Factor in Behavior Leading to Fatal Highway Crashes. *Proceedings of the First Annual Alcoholism Conference of the National Institute of Alcohol Abuse and Alcoholism.* DHEW Publication No. (NIH) 74-675, 1973.
10. Waller, J. A., Factors Associated with Alcohol and Responsibility for Fatal Highway Crashes. *Quarterly Journal of Studies on Alcohol*, 33, 160-170 (1972).
11. Williams, C. L., Henderson, A. S. and Mills, J. M., An Epidemiological Study of Serious Traffic Offenders. *Social Psychiatry* 9, 99-109 (1974).
12. Zylman, R., Accidents, Alcohol and Single Cause Explanations. *Quarterly Journal of Studies on Alcohol* (Suppl. 4), 212-233 (1968).

SECTION II

harmacological, Physiological, and sychological Aspects Relevant to riving Impairment

Program Committee

Head: HAROLD KALANT
J. ANTHONY CARPENTER
HERBERT MOSKOWITZ
HENRIK WALLGREN

Drug Effects on Emotions: Relevance to Driving Accidents

Marianne Frankenhaeuser[1,2]

From the point of view of experimental psychology, traffic safety may be regarded as a problem of adjustment between the driver and his environment. Good adjustment is characterized by a low frequency of accidents combined with high traffic efficiency. Driving accidents represent breakdowns of adjustment. Drugs may either counteract or facilitate the driver's ability to adjust to the demands posed by the environment. I shall begin by considering some basic phenomena related to man-environment interactions.

THE INVERTED-U CURVE

In a normal environment, the individual is aware of only a fraction of the multitude of stimuli to which he is exposed. If, however, the inflow of impulses falls below a critical level, disturbances in brain function and behavior occur. Under the opposite condition, that is, when the stimulus flow exceeds a certain level, adequate functioning is also threatened.

The concept of arousal (or activation) is central to all phenomena related to understimulation and overstimulation. Neurophysiological research has identified the reticular activating system of the lower brain stem as the key mechanism regulating arousal level. This structure – which is sensitive to the action of stimulant and depressant drugs – serves as a kind of homeostat regulating and adjusting input-output relations so as to maintain an optimal level.

The aim of my paper is to consider contributions of laboratory experiments to the understanding of how driving behavior is affected by low and high arousal levels induced by, a) different aspects of the driver's environment, b) by alcohol and other drugs, and c) by drug-environment interactions. I will pay particular attention to the emotional aspects of behavior, at the same time emphasizing the intimate interplay between emotional, motivational and cognitive factors. I shall restrict my presentation to the behavior of normal, healthy persons under the acute influence of low to moderate, single doses of alcohol and some centrally-acting drugs.

[1] Psychological Laboratories, University of Stockholm, 113 85 Stockholm, Sweden.

[2] Financial support from the Swedish Medical Research Council (Project 997) and the Swedish Council for Social Science Research is gratefully acknowledged.

When stated in terms of behavior, arousal refers to an intensity dimension ranging from unconsciousness and sleep to drowsiness, quiet awakening and excitement to disorganized behavior (Figure 1).

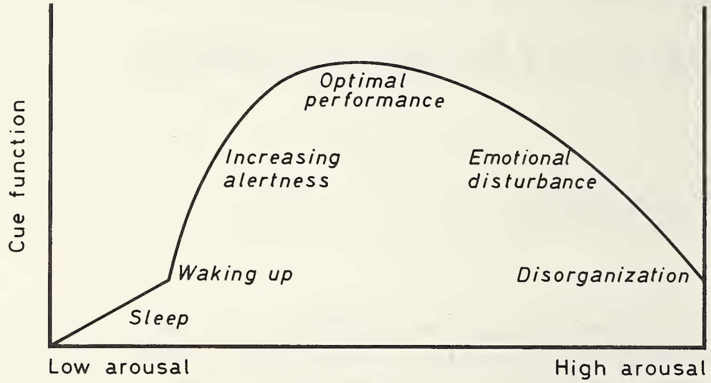


Figure 1 *Postulated relationship between "arousal function" and "cue function". From reference (14).*

According to the arousal theory put forward by Hebb in 1955 (14), stimulation from any source has two functions: a "cue function" guiding behavior – for instance, discrimination, perception and learning – and an "arousal or vigilance function", concerned with general activation and reflected in physiological measures such as the EEG, the EMG, and the GSR as well as in cardiovascular and respiratory measures. Thus, arousal is not a unitary concept; both cortical and autonomic functions are involved.

There is general agreement between arousal theorists in postulating an inverted-U relationship between mental efficiency and arousal level. At low arousal levels the organism tends to be inattentive and easily distracted, and poor performance is probably associated with a slowing down of cortical processes. At somewhat higher arousal levels, the organism's resources are mobilized, full attention is given to the task, and it performs to the best of its abilities. Still higher arousal levels are associated with excessive tension and intense emotion, the decline in performance reflecting impaired cortical control or impaired selectivity of responses.

Safe driving requires medium arousal. At low levels driving performance is characterized by inattention and emotional unresponsiveness, at high levels by disorganization and impulsiveness. Prolonged, uneventful, routine driving represents a condition of stimulus underload and low arousal. Conversely, arousal that is too high is likely to be elicited in driving stiuations characterized by stimulus overload, for example, the confrontation with sudden complex choices or unexpected obstacles.

In a recent review paper, Barry (1) has evaluated the relative danger involved in conditions of low and high arousal, noting that the majority of fatal car accidents with alcohol involvement are single-car accidents. This points to impaired attention and insufficient response to emergency under uneventful conditions as a greater risk factor than impaired ability to manoeuver in complex situations. The type of accident associated with low arousal is driving off the road or into an obstacle, whereas in high-arousal states excessive speeding, risky maneuvers, and loss of control are more likely to occur.

DRUG EFFECTS ON EMOTIONS

Centrally acting drugs, stimulants and depressants, are powerful determinants of arousal level, and drug effects may either enhance or reduce effects of concomitant environmental influences. The largest deviation from an optimal arousal level is likely to occur when a monotonous situation is combined with the action of a depressant drug. Conversely, stimulant drugs may counteract the decreased wakefulness induced by a monotonous situation. Moreover, a stressful environment may counteract the effects of a sedative drug.

Subjective and Objective Reactions to Alcohol

As to effects of alcohol, studies of nerve conduction, of EEG, and of mental performance, all indicate a stimulant action of low doses and a depressant action of moderate and high doses. However, alcohol may have an apparent stimulant action also at high dose levels, since it selectively depresses inhibitory functions (cf. 18). It is this combination of weakening of restraints on behavior and impairment of sensorimotor functions and motor coordination that endangers driving. With regard to higher cognitive functions, such as problem solving and decision making, small doses may have beneficial effects, for instance, by increasing the willingness to try new solutions.

Effects of alcohol on emotions is probably the most complex and the least systematically explored problem area in alcohol research. Information has been obtained mainly by three methods: projective techniques, direct estimates of self-perceived changes in mood, and observations of emotional behavior.

Projective techniques, such as the Rohrschach and the TAT, are useful for measuring feelings and emotions at the subconscious level, which are inaccessible to introspection. Results from studies using these methods indicate that alcohol increases impulsive, uninhibited responses, including aggressive reactions. However, the data are contradictory and difficult to interpret.

I shall concentrate on data obtained from self reports, *i.e.*, from the subjects' own estimates of the changes experienced. This is the method favoured by the Stockholm group, headed by Dr. Anna-Lisa Myrsten, who has been working in my laboratory in close collaboration with Dr. Goldberg's Laboratory for Alcohol Research at the Karolinska Institute. One of the initial collaborative efforts of these two laboratories was to develop methods by which subjective intoxication – induced by alcohol in small to moderate doses – could be quantified. For this purpose we adopted the method of magnitude estimation, which is the simplest direct scaling method. Figure 2 shows mean blood-alcohol concentration in a group of subjects, plotted over time, and their self-estimates of intoxication at corresponding points in time after intake of .55 g alc/kg body weight, taken as whisky, on an empty stomach.

The method of magnitude estimation, by which the subjective curve was obtained, deserves comment (for a detailed account see reference (7)). In order to apply this scaling method to measuring the degree of intoxication, a "standard state" of comparison had to be defined outside the experimental situation. We used as a

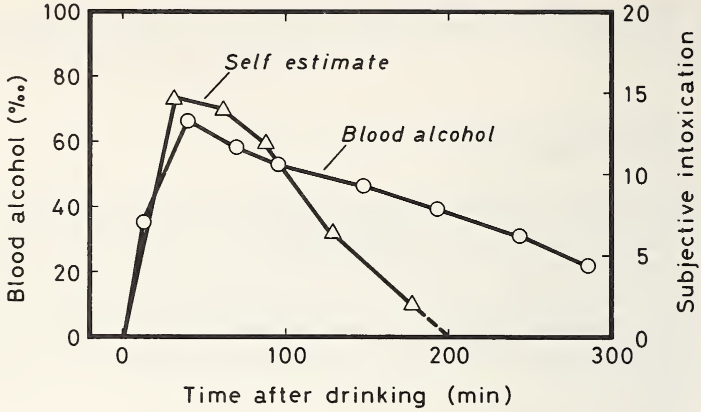


Figure 2 *Mean values for blood-alcohol concentration and subjective intoxication after intake of 0.55 g alc/kg body wt. Redrawn after reference (13).*

standard the degree of intoxication defined as "a little high" which was denoted 10. If the subject felt twice as intoxicated as his conception of the standard he should report 20, if he felt half as intoxicated his estimate should be 5 and so on.

In a general way, the subjective curve obtained by this method resembles the blood-alcohol curve. The rapid growth is seen for both parameters, and the peaks coincide approximately in time, being located at about 30-40 minutes after consumption. In the later phase, however, the two curves differ considerably in that subjective intoxication declines more rapidly than blood alcohol concentration. In other words the subjects felt sober while there was still alcohol in their blood. This phenomenon has been repeatedly demonstrated in investigations in our laboratory (for a review see reference (16)). Moreover, the larger the quantity of alcohol consumed, the higher the blood alcohol level at which the subject reports feeling completely sober. Needless to say, this discrepancy between blood alcohol and subjective intoxication represents a danger zone, characterized as it is by reduced awareness of impaired driving ability.

The next step is to identify the specific emotional components involved in the concept of subjective intoxication. To this end, we always ask our subjects to estimate different aspects of mood. The data in Figure 3 were obtained in an earlier experiment but under similar conditions. In this case the scale value 10 denotes the subject's 'normal' state serving as a standard of comparison in terms of each variable. The euphoric, exhilarated, carefree, happy mood predominates during the absorption phase and is succeeded by feelings of tiredness. Irritation is another commonly occurring negative symptom in the later intoxication phase. This picture is typical for small to moderate alcohol doses. After large doses, when blood alcohol exceeds 1.2 mg per ml, feelings of discomfort appear already during absorption.

Psychosocial and Cognitive Factors

The quality and intensity of the various components of the intoxication pattern are modified by the psychosocial setting in which drinking takes place as well as by motivational and cognitive characteristics of the individual. Mood changes tend to be less pronounced in a laboratory setting than in a social drinking situation. Thus, results from laboratory studies may lead to an underestimation of behavioral effects of alcohol. Moreover, in laboratory situations, the elation that typically occurs during the initial phase, is much more pronounced when the subjects are in a group together than when they sit by themselves. Likewise, the euphoria is much less marked when alcohol is given by intravenous infusion. These observations tell us two things. Firstly, they underscore the importance of psychosocial determinants of alcohol effects. Secondly, they point to the limited generalizability of data from one condition of alcohol consumption to another. Or, to quote from Bowman, Rand and West (3): "In stimulating

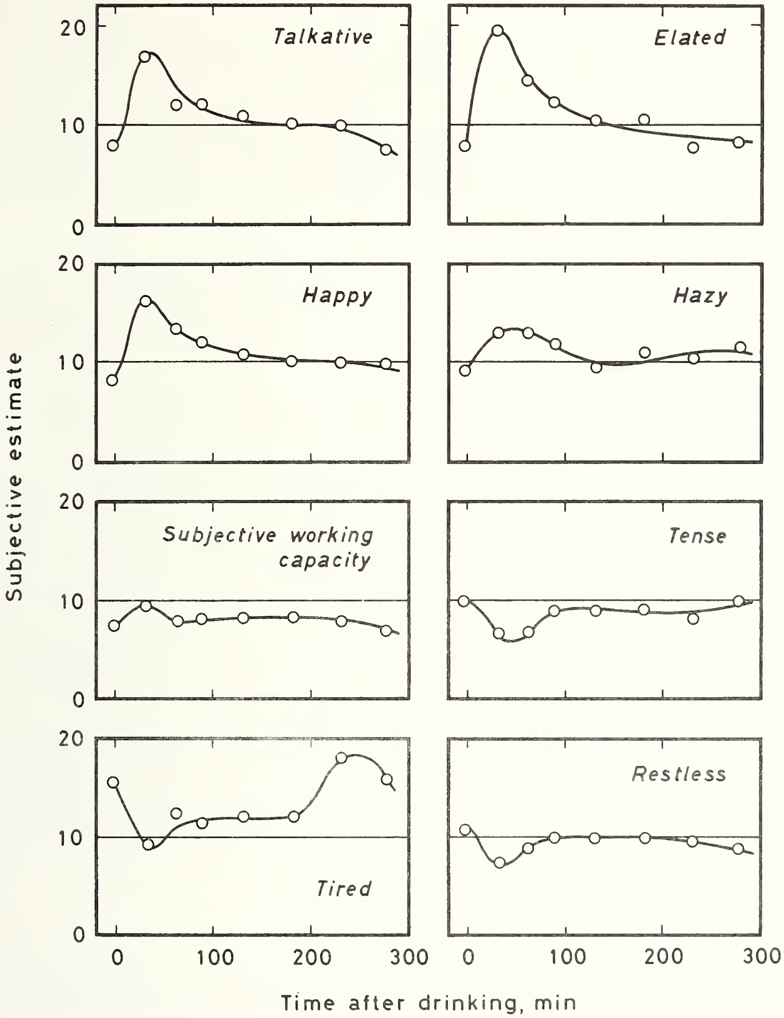


Figure 3 *Mean estimates of different aspects of mood after intake of 0.55 g alc/kg body wt. From Ekman, Frankenhaeuser, Goldberg, Bjerver, Järpe and Myrsten,* Psychopharmacologia 4, 1963.

surroundings, the drinker may become expansive, over-confident and excited, or noisy and aggressive. But in other surroundings, especially when alone, the drinker may become morose, dull, and sleepy."

The problem of alcohol and aggression has been approached in laboratory studies, for example, by using the technique developed by Buss (4) in which one subject delivers electric shocks to another subject – the victim – in such a way that the shocks that he chooses to give can be scaled for intensity. It is assumed that changes in shock intensity reflect changes in aggression. The out-come of these experiments indicate that alcohol alone, in an emotionally neutral setting, does not influence the level of aggression as measured in this manner. However, in a social context, where there is a group interaction, an increase in aggressive behavior and aggressive feelings may occur, depending upon the characteristics of both the individual and the situation. At this point I want to call attention to a review by Carpenter and Armenti (5) on the subject of alcohol and aggression.

In this connection it is interesting to consider the hypothesis put forward by Berkowitz (2), stating that arousal interacts with aggressive cues in the environment to produce aggressive responses. This suggests that states of heightened arousal following intake of small doses of alcohol may increase the tendency of a person to react aggressively to, for example, competitive elements in the driving situation. For large alcohol doses, however, sedative indifference is a more likely reaction. This, in turn, may be paired with self-destructiveness, a strong motive in road accidents.

Important in this context is also the influence of expectations. Pharmacologically inert substances, placebos, are useful tools for studying the mechanisms by which drugs and expectations interact. Since it is difficult to find a completely satisfactory placebo for alcohol, I shall illustrate effects of expectations by data from an experiment in which we gave either white or pink capsules to our subjects on two different occasions (10). The white capsules were said to contain a sleeping powder, the pink capsules a stimulant, whereas in reality all capsules contained a placebo. The results showed (Figure 4) that the 'depressant' placebo and the 'stimulant' placebo produced marked effects in opposite directions. After the 'depressant' placebo subjective alertness decreased, the subjects felt that they performed more slowly in a reaction-time test, and, in fact, their speed of performance decreased. Pulse rate and blood pressure also decreased, all in relation to a pre-treatment trial. In contrast, after the 'stimulant' placebo there was an increase in subjective wakefulness. The subjects *felt* quicker, they *were* quicker, and there was a slight increase in heart rate and blood pressure.

In another experiment (12) we found that a placebo introduced as a depressant drug had more powerful depressant effects than had the actual drug given without suggestive instructions.

These are striking illustrations of the modifying influence of cognitive factors on drug effects. Moreover, data such as these point to the hazards involved in predicting the behavioral reactions that a particular drug will elicit. Obviously, drugs – like other stimuli – take on different characteristics depending upon the subject's expectations and the psychosocial setting.

I have concentrated on these problems because they illustrate the point that I am particularly anxious to make: effects of drugs on driving behavior are only partly determined by the pharmacological properties of the drug. The driver's cognitive

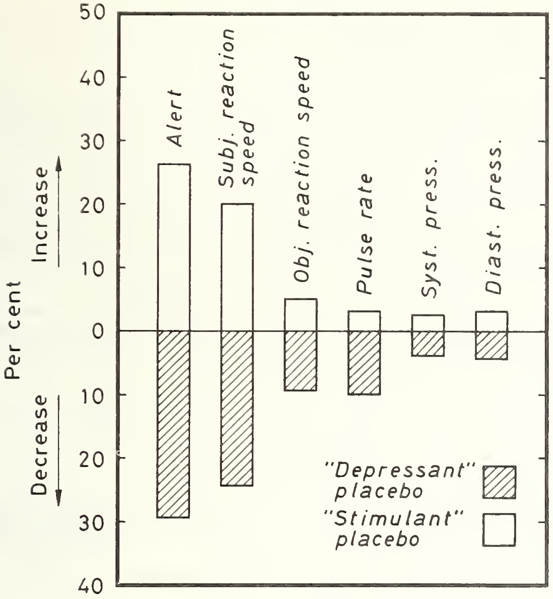


Figure 4 *Mean per cent increase and decrease in objective and subjective reactions produced by a "depressant" and a "stimulant" placebo. from reference (10).*

appraisal of his own state and of the external situation will guide his choices and decisions. This view is consistent with the basic ideas in Schachter's (17) cognitive theory of emotion.

RISK TAKING

This takes us to the question of drug effects on risk taking. Before discussing effects of alcohol, I shall briefly review results from laboratory experiments with barbiturates and amphetamines, which permit the separate study of depressant and stimulant components of risk-taking behavior.

Actual and Estimated Performance

In these experiments (11) emphasis was placed on relations between actual and self-perceived reactions to the drugs; in particular the subject's own awareness of the changes in his performance. We wanted to know if our subjects were able to estimate correctly the improvements and impairments in performance following intake of central stimulants and depressants.

Measures of performance speed were obtained by a battery of sensorimotor and perceptual tests given to a group of students before and after intake of either 15 mg of dexamphetamine, 200 mg of pentobarbitone, or a placebo (Figure 5). The diagram on the left in Figure 5 shows the mean results in each of six successive trials spread over five hours. Estimates of subjective speed of performance (the diagram on the right) were obtained by the method of magnitude estimation. After each trial, the subject estimated changes in his performance in relation to the previous trial. In the diagrams, post-treatment measures have been expressed in per cent of pre-treatment levels for objective and subjective speed, respectively.

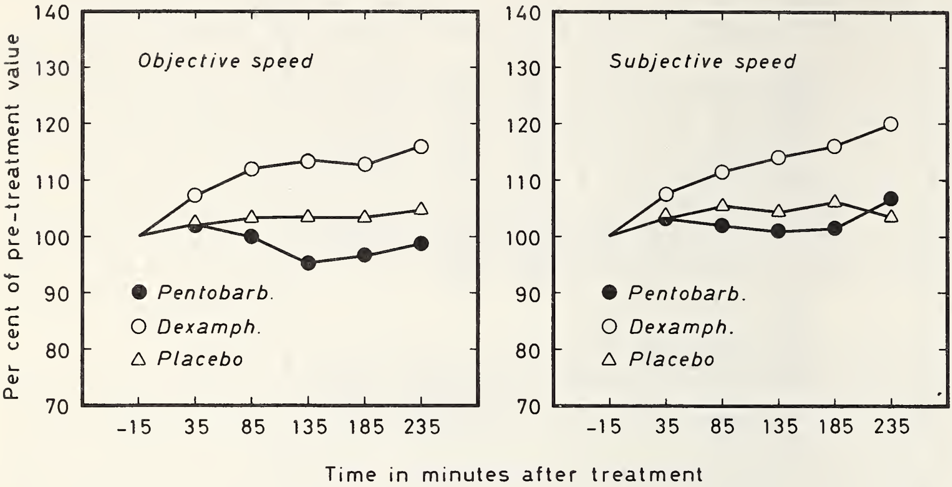


Figure 5 *Objective and subjective performance speed after dexamphetamine, pentobarbitone, and a placebo. Reference (11).*

It is seen (a) that in the placebo condition both objective and subjective speed remained relatively constant, and (b) that the two drugs in accordance with our predictions affected both variables in opposite directions: after dexamphetamine the subjects performed more quickly and felt quicker, while after pentobarbitone they were slower and, also, tended to feel somewhat slower. The interesting point, however, is the quantitative relation between actual and perceived drug effects. In Figure 6 subjective speed has been plotted against objective speed. Each point corresponds to one trial. It is seen that the points referring to the three conditions form three distinct clusters. The diagram shows a general tendency for over estimation, which is particularly pronounced for the low level of performance induced by the depressant. Since improvements were only slightly overestimated after dexamphetamine, these data do not support the commonly held view that stimulants give rise to an exaggerated belief in one's own ability. Instead, the depressant drug induced a relatively greater overestimation of performance speed. With regard to alcohol this would mean that drivers are most likely to overestimate their ability after moderate and large doses inducing depressant effects.

Time Estimation

In this connection it is important to note that stimulants and depressants influence time estimation in opposite directions. In Figure 7 time estimates (in seconds) have been plotted against physical time, and it is seen that one and the same time period regularly appeared longer after the stimulant, metamphetamine, than after the depressant, pentobarbitone (8). Hence, it seems likely that the differences in estimates of performance speed, as seen in Figures 5 and 6, were associated with changes in subjective time, time seeming to pass more quickly after the depressant than after the stimulant drug.

Within the same series of experiments (8) we have found that caffeine produces effects on time estimation similar to amphetamines, while nitrous oxide produces effects similar to barbiturates. Results from alcohol studies obtained by other investigators fit into the picture, showing that alcohol in doses sufficiently large to cause depressant effects, will make time pass subjectively more quickly. In contrast, alcohol in small doses with stimulant effects causes time to pass subjectively more slowly. This may result in feelings of impatience associated with a tendency to drive too fast. However, dose-response relationships for alcohol, time estimation and speed of driving have not been examined systematically.

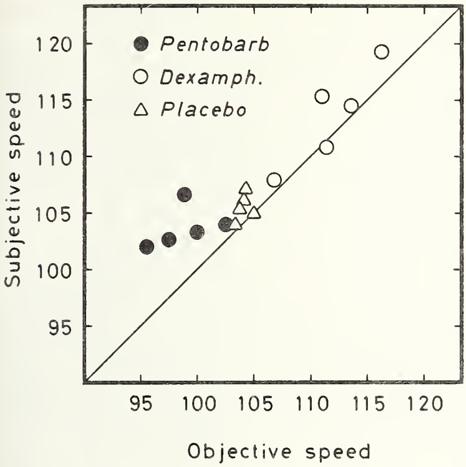


Figure 6 *Relation between subjective and objective performance speed after dexamphetamine, pentobarbitone, and a placebo. Each point refers to one trial. Reference (11).*

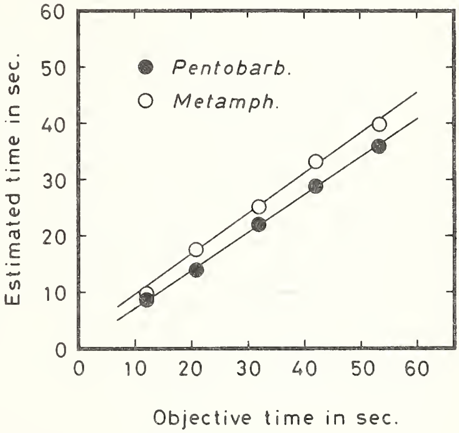


Figure 7 *Time estimates after the intake of metamphetamine and pentobarbitone. From reference (8).*

Fear Reduction

Returning to our analysis of risk-taking behavior, we may conclude that the reason why the intoxicated person tends to overestimate his own ability and choose the risky alternative is partly of a cognitive nature: he underestimates the impairments caused by alcohol. The well-known investigation by Cohen *et al.* (6) using professional drivers, showed that alcohol affects their judgment of the size of the narrowest gap through which they could drive, the size of the gap varying inversely with the alcohol dose.

Among emotional factors, fear reduction is an important component in risk-taking behavior. It is well known since the animal experiments by Masserman (15) that alcohol may facilitate the solving of approach-avoidance conflicts by reducing fear and frustration. Accordingly, alcohol intoxication increases the probability that a driver, faced with complex choices, will make bold, risky decisions. Fear reduction may also manifest itself as aggressive behavior.

COUNTERACTING ALCOHOL INTOXICATION BY STRESS

So far, I have considered the fear-reducing and stress-alleviating actions of alcohol.

This is but one part of the complex interactions between alcohol and stress. Equally important is the fact that fear and stress may, under some circumstances, counteract the depressant effects of alcohol. Thus, acute fear or trauma may have a sudden sobering effect on intoxicated individuals. On the behavioral level this sobering effect is often described as "pulling oneself together" and interpreted as a compensatory reaction which serves to restore homeostatic balance. The strong compensatory response to alcohol may account for the fact that a severely intoxicating dose is often needed to cause impairment. This, in turn, implies that the difference between an ineffective dose and a totally incapacitating dose may be very small. In this connection it is interesting that the rapid compensatory response to the intoxicating action of alcohol is manifested in the development of acute tolerance, so that the same blood alcohol concentration has less effect during its falling than during its rising phase.

According to several reports – reviewed by Wallgren and Barry (18) – stressors such as pain, exertion, fatigue, and cold, tend to enhance the ability of subjects under the influence of alcohol to pull themselves together. Results from animal experiments by Wallgren's group in Finland show how psychological stress may reduce the alcohol-induced impairment of psychomotor functions (19). Data from human studies point in the same direction although most of the evidence is indirect. However, in a recent investigation (12), we obtained convincing support for the hypothesis that mild psychological stress counteracts the detrimental effects of a moderate dose of alcohol.

Our main aim was to obtain quantitative measures of the stress-induced reduction of the impairment of performances following alcohol intake. We were particularly interested in effects on psychomotor functions representing different levels of task difficulty. Alcohol was given as whisky in a dose of .55 g alc/kg body weight in the morning following a light breakfast. The stressor consisted of relatively mild electric shocks applied to two fingers of one of the subject's hands. Figure 8 shows performance in tasks on simple, two-choice, and four-choice reaction time in each of four experimental conditions. The mean value for each condition is expressed in per cent of the pre-treatment value. It is seen that (a) performance remained close to the pre-test level in the control condition, (b) performance in all three tasks was improved by electric shock, (c) performance in two-choice and four-choice tasks was impaired by alcohol, and (d) electric shocks reduced the alcohol-induced impairment.

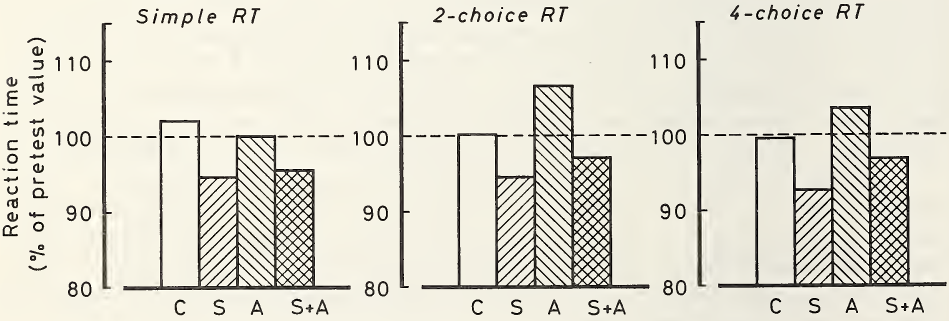


Figure 8 *Mean reaction time for simple, 2-choice, and 4-choice tasks expressed in per cent of pretest value (100) during a control condition (C) and conditions involving electric shock (S), alcohol intake (A), and shock + alcohol (S+A). From reference (9).*

When interpreting these results it should be noted that the subjects were under pressure from the performance tasks which demanded a great deal of attention and thus counteracted the carefree, happy mood which is typical of this intoxication level. Instead, the situation had an arousing effect as reflected in measurements of heart rate and adrenaline excretion, and in self-estimates of wakefulness and mood. However, even under these circumstances the additional stress induced by electric shock significantly reduced the impairment of performance produced by alcohol. In other words: the "pulling oneself together" effect was markedly enhanced by adding a relatively mild stressor to an already tense situation.

Although the mechanisms underlying the stress-induced reduction of intoxication is not yet understood, it is reasonable to assume that compensatory effects are mediated by physiological arousal reactions. Here we should recall the inverted-U curve (Figure 1) relating performance to arousal. Electric shock, in the experiments just described, increased arousal sufficiently to counteract the alcohol-induced decrease and maintain performance at an optimal level. On the neurophysiological level this may be interpreted as indicating that the depressant effect of alcohol on the reticular activating system was partially counteracted by a generalized arousal reaction.

Support for the view that compensatory effects are mediated by arousal reactions is provided also by the analysis of individual differences in sensitivity to alcohol which suggest that highly anxious individuals tend to have a high alcohol tolerance as determined by behavioral effects (cf. 18). Several reports point to a positive relationship between high levels of emotionality and resistance to intoxication. It is worth noting that variations in arousal might account for some of the differences among individuals in performance decrements induced by the same amount of alcohol. I shall not attempt to cover the problem of personality factors and drug action, but only note that some of the ongoing research (e.g. 20) may aid in detecting high-risk individuals and groups with regard to traffic accidents with drug involvement.

CONCLUSION

The combination of depressant and disinhibitory effects elicited by alcohol contribute to enhanced risk taking which, in turn, is an important contributing factor in traffic accidents. Reduced fear, increased aggressiveness and assertiveness, increased tendency towards self-destruction, all form part of a complex emotional pattern, which cannot be understood by taking into account the pharmacological actions only. Instead, pharmacological effects have to be considered in relation to the psychosocial environment as perceived by the individual. Personality factors and other constitutional characteristics interact with situational factors in determining the response.

Thus, from the point of view of behavioral science, the outstanding characteristic of the problem of drugs, alcohol, emotion and driving is its immense complexity. However, as we have seen, it is possible to extract specific sub-problems from real-life driving and drinking situations and bring them into the laboratory where they can be examined under controlled conditions.

Admittedly, there is a discrepancy between the rather crude tools that the experimental psychologist has at his disposal and the subtle, intricate problems of human emotions. Nevertheless, continued efforts along the lines of research that I have outlined are likely to be rewarding in the long run.

REFERENCES

1. Barry, H., Motivational and Cognitive Effects of Alcohol, *Journal of Safety Research* 5, 200-221 (1973).
2. Berkowitz, L., The Frustration-Aggression Hypothesis Revisited. In *Roots of Aggression: A Re-examination of the Frustration-Aggression Hypothesis,* L. Berkowitz, (ed.), Atherton Press, New York, 1969.
3. Bowman, W. C., Rand, M. J. and West, G. B. *Textbook of Pharmacology.* Blackwell Scientific Publications, Oxford, 1968.
4. Buss, A. *The Psychology of Aggression.* Wiley, New York, 1961.
5. Carpenter, J. A. and Armenti, N. P., Some Effects of Ethanol on Human Sexual and Aggressive Behavior. In *The Biology of Alcoholism. Vol. 2: Physiology and Behavior,* Kissin, B. and Begleiter, H. (eds.), pp. 509-543. Plenum Press, New York-London, 1972.
6. Cohen, J., Dearnaley, E. J. and Hansel, C.M.E., The Risk taken in Driving under the Influence of Alcohol, *British Medical Journal* 1, 1438-1442 (1958).
7. Ekman, G., Frankenhaeuser, M., Goldberg, L., Bjerver, K., Järpe, G. and Myrsten, A.-L., Effects of Alcohol Intake on Subjective and Objective Variables over a Five-hour Period, *Psychopharmacologia* 4, 28-38 (1963).
8. Frankenhaeuser, M. *Estimation of Time. An Experimental Study.* Almqvist & Wiksell, Stockholm, 1959.
9. Frankenhaeuser, M., Dunne, E., Bjurström, H. and Lundberg, U., Counteracting Depressant Effects of Alcohol by Psychological Stress, *Psychopharmacologia* (1974). (In press.)
10. Frankenhaeuser, M., Järpe, G., Svan, H. and Wrangsjö, B., Psychophysiological Reactions to Two Different Placebo Treatments, *Scandinavian Journal of Psychology* 4, 245-250 (1963).
11. Frankenhaeuser, M. and Post, B., Objective and Subjective Performance as Influenced by Drug-induced Variations in Activation Level, *Scandinavian Journal of Psychology* 7, 168-178 (1966).
12. Frankenhaeuser, M., Post, B., Hagdahl, R. and Wrangsjö, B., Effects of a Depressant Drug as Modified by Experimentally-induced Expectation, *Perceptual and Motor Skills* 18, 513-522 (1964).
13. Goldberg, L. and Myrsten, A.-L., Alkoholens akuta effekter på mentala funktioner, *Läkartidningen* 71, 947-953 (1974).
14. Hebb, D.O., Drives and C.N.S. (Conceptual Nervous System), *Psychological Review* 62, 243-254 (1955).
15. Masserman, J. H. and Yum, K. S., An Analysis of the Influence of Alcohol on Experimental Neuroses and Cats, *Psychosomatic Medicine* 8, 36-52 (1946).
16. Myrsten, A.-L., Effects of Alcohol on Psychological Functions. Experimental Studies on Non-alcoholic Subjects. *Reports from the Psychological Laboratories,* The University of Stockholm, Supplement 7, 1971.
17. Schachter, S. The Interaction of Cognitive and Physiological Determinants of Emotional State. In *Anxiety and Behavior,* C. D. Spielberger (ed.). Academic Press, New York, 1966.
18. Wallgren, H. and Barry III, H., *Actions of Alcohol.* Elsevier, Amsterdam, 1970.
19. Wallgren, H. and Tirri, R., Studies of the Mechanism of Stress-induced Reduction of Alcohol Intoxication in Rats, *Acta Pharmacologica & Toxicologica* 20, 27-38 (1963).
20. Zelhart, P. F., Types of Alcoholics and their Relationship to Traffic Violations, *Quarterly Journal of Studies on Alcohol* 33, 811-813 (1972).

The Pharmacokinetic Component of Drug Effects on Driving Skills

Edward M. Sellers[1,2]

Studies of drug effects on driving skills attempt to determine if a specific dose of a drug has some predictable influence on a particular driving related task. The purpose of such studies is to provide experimental evidence of the importance of concurrently taken medication in the etiology of motor vehicle accidents. Our present research tactics will not permit us to conclude, with any degree of certainty, that, in a particular individual, a specific drug or drug combination is or is not, contributory to driving impairment. There are marked inter-individual differences in drug disposition in the body and the failure to recognize these differences has confounded interpretation of most studies.

During the past decade the need to individualize drug dosages, to minimize toxicity and maximize therapeutic effectiveness of many drugs has been clearly established (30). The use of a 'standard dosage' regimen would be unthinkable for patients receiving the anticoagulant warfarin, or the antihypertensive agents, guanethidine, propranolol or methyldopa. These are drugs where dose is titrated to obtain an easily measurable therapeutic effect, such as a satisfactory lowering of blood pressure. Such readily available and reliable indices of therapeutic effect do not exist for analgesics, antiepileptics, antidepressants or anxiolytic agents (46). As a result, in contrast to drugs with which the necessity to individualize dosages is readily accepted, clinicians and scientists give standard or recommended doses of these other agents and expect 'standard' responses. There is, in fact a wide variation in response to standard dosages of psychoactive drugs. This is not surprising when one considers the many factors which influence the relation of the dose of a drug and the pharmacologic effect (Figure 1). In contrast to the variable relation of drug dose and effect, the relation between the serum concentration of drug and effect is more constant. Therefore, variations in response reflect in large part variations in serum drug concentration after a dose. For most drugs which bind reversibly at their site of action, changes in serum concentration are accompanied by proportionate changes in concentration at the 'site of action' and a proportionate increase in the magnitude of the response. Complicating this relationship is the fact that both concentration and pharmacologic 'responsiveness'

---

[1] Clinical Institute, Addiction Research Foundation, 33 Russell Street, Toronto, Ontario, Canada M5S 2S1.

[2] I am indebted to Dr. David Greenblatt, Clinical Pharmacology Unit, Massachusetts General Hospital for providing Figure 7 and Mrs. Maureen Stewart for assistance in preparation of the manuscript.

may change with time. With psychoactive drugs, the development of tolerance may therefore make the relationship between concentration and effect less obviously related to concentration than with other classes of drugs.

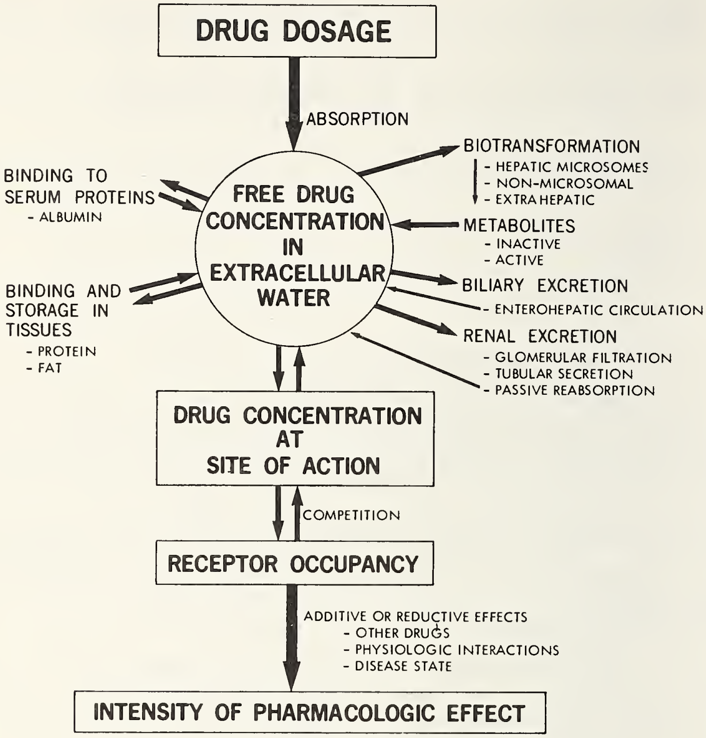


Figure 1 *Factors influencing the relation of drug dosage to intensity of pharmacologic effect.*

Among the factors which can alter the relation of drug dose and serum concentration are the bio-availability of the dosage form administered, the completeness or rate of absorption, body size and composition, rates of biotransformation in the liver or elimination by the kidney or in the bile and binding of drug to tissue or serum proteins (Figure 1). There are marked inter-individual differences in each of these due to genetic factors, co-existing disease and the concurrent administration of other drugs.

The extent of inter-individual differences in the relation between dose and drug concentration has seldom been recognized in studies of drug effects on driving skills. Instead, typically, standard doses are given, usually as single doses, with the expectation of standard response. The extent of inter-individual variation in serum concentration after standard doses is such that the conflicting statements in the literature on drug effects on driving skills is not surprising.

This paper discusses the extent and source of inter-individual variations in metabolic fate of drugs other than alcohol. The literature reviewed includes all articles cited in the bibliographic series Drug Use and Driving (20) updated to August 31st., 1974, as well as other pertinent articles.

BACKGROUND: DEFINITIONS AND CALCULATIONS

Biological Drug Half-life

After single intravenous injection of drug, the serum drug concentration typically falls at a rate proportional to concentration (first-order elimination). During the first 30 minutes after injection, drug concentration falls quickly (alpha-phase) due to mixing of the drug in the plasma compartment, and rapid diffusion into extracellular fluid. If this initial phase (Figure 2) last longer than approximately 30 minutes, then extensive entry of the drug into less well perfused compartment is occurring, e.g., fat. The curve in Figure 2 can be mathematically described by 2 exponential functions of the form

$$C_p = C_o e^{-k_e t}$$

C_p = plasma concentration

C_o = concentration at zero time obtained by extrapolation of the α and β phases of the curve.

k_e = elimination rate constant

$$k_e = \frac{.693}{\text{half-life } (t_{1/2})}$$

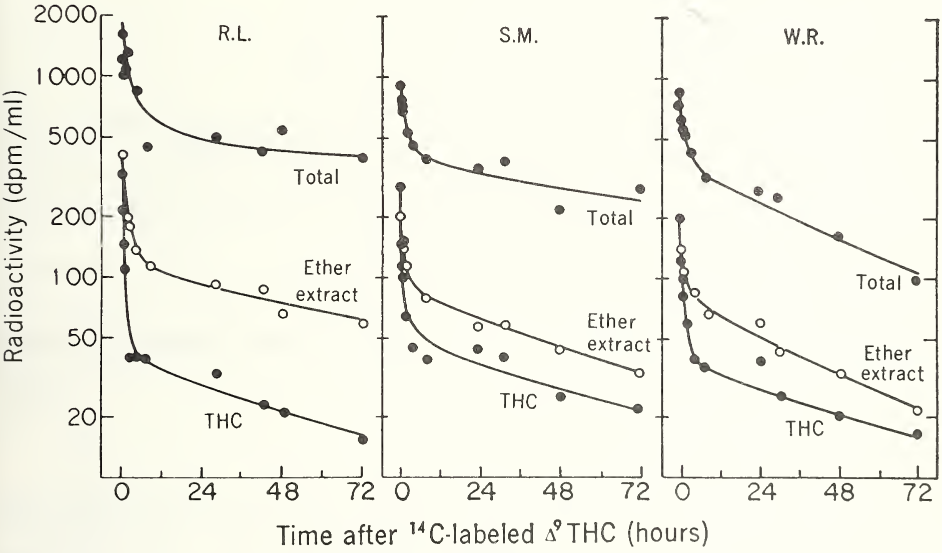


Figure 2 *Plasma concentrations of 14_C – labelled Δ^9 tetrahydrocannabinol (reproduced with permission reference (34)). Copyright 1970 by the American Association for the Advancement of Science.*

Frequently, psychoactive drugs have patterns of elimination which are more complex and require more than two exponential terms to satisfactorily describe them. Drugs which show such multi-exponential elimination from plasma include diazepam (19), pentobarbital (48), tetrahydrocannabinol (34), morphine (6), methaqualone (3), and reserpine (26).

The second and slower phase of the curve, often called the beta-phase (β), is due to elimination of the drug. Elimination of the drug is due to biotransformation in the liver and/or excretion of drug through the kidneys or bile. The time it takes this terminal serum concentration to fall by 50% is called the serum half-life ($t_{1/2}$). This pharmacokinetic parameter is extremely useful. From the half-life, simple calculations can be made to determine intervals between doses and rates of cumulation of drug. Figure 2 indicates the pattern of elimination of tetrahydrocannabinol, and indicates two general kinetic features of psychoactive drugs; the rate of elimination of drug is slow, and there is considerably variation among subjects in the terminal elimination phase. Table 1 summarizes the ranges in terminal half-lives for various psychoactive drugs. Since half-life is so variable, the pharmacologic effects in different individuals will be variable. Knowledge of an 'average' drug half-life is not helpful with the large differences in half-life found among subjects.

Apparent Volume of Distribution (V_D)

This parameter is the proportionality factor between the amount of drug in the body ($X_B{}^{ss}$) and mean plasma[3] drug concentration ($C_p{}^{ss}$) at the steady state.

$$X_B{}^{ss} = V_D \cdot C_p{}^{ss}$$

An estimate of V_D for a drug with a long half-life is:

$$V_D = {}^{Do}\!/_{C_o} = \frac{{}^{D_o}\!/_{t_{1/2}}}{\text{Area X } 0.693}$$

D_o is the dose; C_o is the plasma drug concentration when the terminal disposition phase is extrapolated to time zero. The area is the total area under the plasma (or serum) curve (AUC) versus time. The volume of distribution is a hypothetical volume; it indicates nothing about the *actual* distribution or concentration of the drug in any part of the body.

Bioavailability (F)

This is calculated by comparing the areas of plasma concentration curves after oral (p.o.) and intravenous (i.v.) drug doses.

$$F = {}^{AUC_{p.o.}}\!/_{AUC_{i.v.}}$$

Some therapeutic drugs are subject to "first-pass" biotransformation after oral dosing (Figure 3). Such drugs have high extraction into the liver and a substantial fraction of the oral dose is biotransformed, as the portal blood from the site of drug absorption passes through the liver before mixing with the general circulation. Estimates of bioavailability under these circumstances can be obtained from

$$F = 1 - \text{Dose}_{i.v.} / \dot{Q}_L \cdot \text{AUC}_{i.v.}$$

$\dot{Q}_L$ is plasma or blood flow through the liver.

---

[3] The term serum is often used interchangeably with plasma.

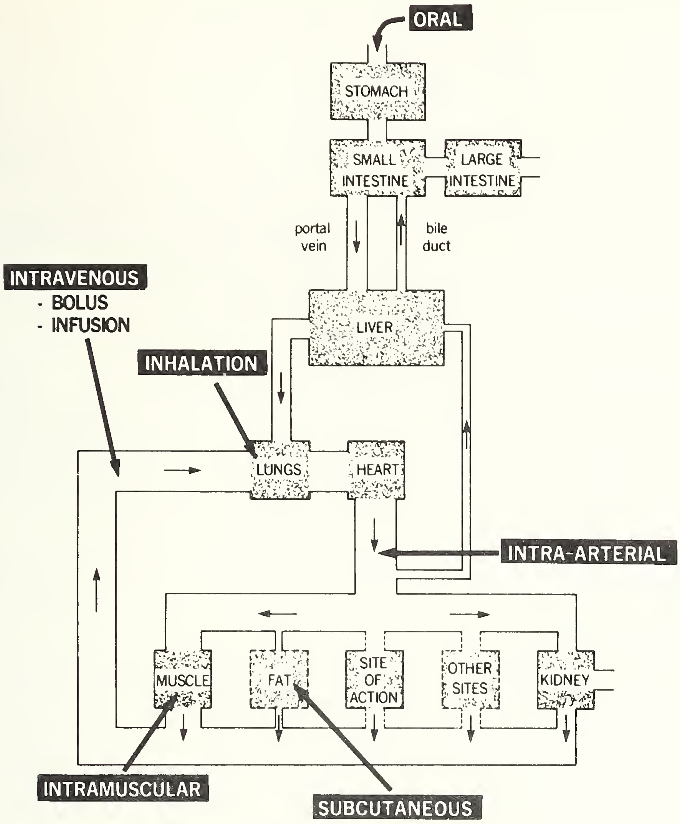


Figure 3 *Modes of drug administration and pattern of distribution.*

Metabolic or Plasma Clearance (Cl_m)

This parameter reflects the overall rate of removal of a drug from the body and provides the explicit statement of the relation between dose (D_o) bioavailability (F), interval between drug doses (τ) and the mean steady state plasma drug concentration $C_p{}^{ss}$.

$$Cl_m = 0.693\ V_D/t_{1/2}$$

$$C_p{}^{ss} = \frac{F\ .\ D_o}{Cl_m \cdot\ \tau}$$

combining above equations

$$C_p{}^{ss} = \left[\frac{1.44\ .\ F\ .\ D_o}{\tau}\right] \cdot \frac{t_{1/2}}{V_D} \quad \text{(Equation 1)}$$

The initial portion, in brackets, is usually constant for any drug and dose regimen. Therefore, variations among subjects in $C_p{}^{ss}$ reflect inter-subject variations in plasma half-life and/or volume of distribution for that drug. There is a wide variation in both of these amongst psychoactive drugs.

EXPERIMENTAL EVIDENCE FOR INTER-INDIVIDUAL VARIATION IN DRUG EFFECT

Alcohol-Diphenydramine

Table II summarizes results from a study of the interaction of diphenhydramine and alcohol on a co-ordination test and selected driving time (36). Comparison of the no treatment and alcohol 0.5 g/kg groups to the groups getting diphenhydramine and alcohol indicates that inter-subject variation in performance increases. These variations between subjects could be explained by differences in receptor responsiveness but this explanation is not tenable until inter-subject variations in fate of the diphenhydramine in the body is ruled out.

TABLE I *Terminal Half-Lives of Psychoactive Agents*

Agent	Half-Life (hours)	Reference
Amitriptyline	15-30[a]	(5)
Chlordiazepoxide	7-28	(19)
Chlorpromazine	30	(11)
Diazepam	26-53	(19)
Diphenylhydantoin	7-73	(46)
Ethinamate	2.3	(9)
Glutethimide	40	(13)
Heptabarbital	9.7	(9)
Imipramine	15-30[a]	(40)
Meprobamate	11-15	(21)
Methadone	10-47	(23)
Methaqualone	19.6-41.5	(3)
Morphine	10-44	(49)
Nortriptyline	18-38	(17)
Oxazepam	8.8-21.2	(19)
Pentobarbital	42-46	(48)
Propoxyphene	24[a]	(50)
Reserpine	271	(39)
Secobarbital	24-33	(9)
Tetrahydrocannabinol	52-66 (Nonusers) 24-29 (users)	(35)

[a] approximate

TABLE II *Percent Variation Among Subjects: Alcohol – Diphenhydramine Interaction*[a]

Drug	Number of Mistakes in Co-ordination Test II at 30 minutes	Driving Time (sec) at 30 minutes
No treatment	55	26
Alcohol 0.5 g/kg	75	31
Diphenhydramine 25 mg	64	40
Diphenhydramine 50 mg	163	42
Diphenhydramine 25 mg + Alcohol	139	48
Diphenhydramine 50 mg + Alcohol	100	44

[a] Date calculated from Tables I and III, reference (36). Percent variation = standard deviation/mean x 1

Table III shows a similar increase in inter-subject variation when diazepam is present, in a study of diazepam and alcohol interaction (36). The increase in variation persists throughout the duration of the study. There is marked inter-individual variation in the metabolism of benzodiazepine minor tranquillizers (19), e.g., diazepam, and it is likely that the failure to elicit standard responses in these subjects reflects these differences.

TABLE III *Percent Variation Among Subjects in Selected Driving Time: Alcohol-Diazepam Interaction*[a]

Drug(s)	Time After Drug Administration		
	30 min	90 min	150 min
Alcohol 0.5 g/kg	31	28	18
Alcohol 0.8 g/kg	37	28	22
Diazepam 5 mg + alcohol 0.5 g/kg	29	34	33
Diazepam 5 mg + alcohol 0.8 g/kg	42	42	29
Diazepam 10 mg + alcohol 0.5 g/kg	50	42	35
Diazepam 10 mg + alcohol 0.8 g/kg	49	39	34

[a] Data calculated from Table VIII of reference (37). The driving time was measured on Co-ordination Test II in which subjects choose their own preferred driving speed. Percent variation = standard deviation/$_{\text{mean}}$ x 100.

SOURCES AND EXTENT OF VARIATIONS

A drug injected intravenously passes to the lungs and heart and then to the systemic circulation (Figure 3). About 25% of the cardiac output each minute goes to the liver where the drug undergoes biotransformation to inactive or active metabolites. Drug also goes to muscle, fat, kidney, other tissue compartments and to the site of action. Most psychoactive drugs are highly lipid soluble and therefore tend to localize in fat (26). One consequence of this localization is that serum concentration may be low.

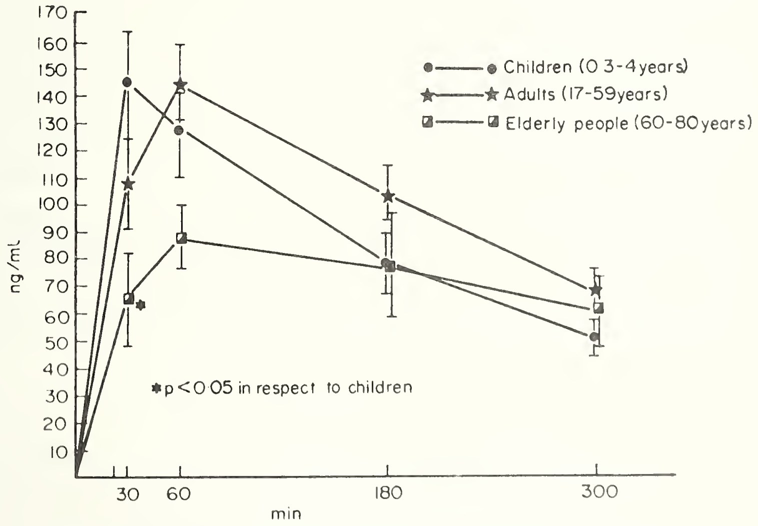


Figure 4 *Diazepam blood levels in children, adults and elderly people after a single oral dose (0.25 mg/kg) (reproduced with permission reference (17).*

Absorption

Variations in extent and/or rate of absorption can importantly influence the serum drug concentration. In general the presence of food slows absorption. Factors influencing the rate of rise of drug concentrations are of particular relevance to studies of acute tolerance after oral administration of drugs.

Figure 4 shows the variability in plasma diazepam concentrations after fixed single oral doses to groups of individuals (17). Peak concentrations appear earlier in children than adults, while the rate of disappearance is slower in elderly patients. This variability is accounted for on the ascending side of the drug concentration curve by differences in rates of absorption, possibly because of more rapid gastric emptying, while on the descending side differences are primarily due to difference in rates of biotransformation. Slower rates of absorption result in lower and later peak diazepam concentration.

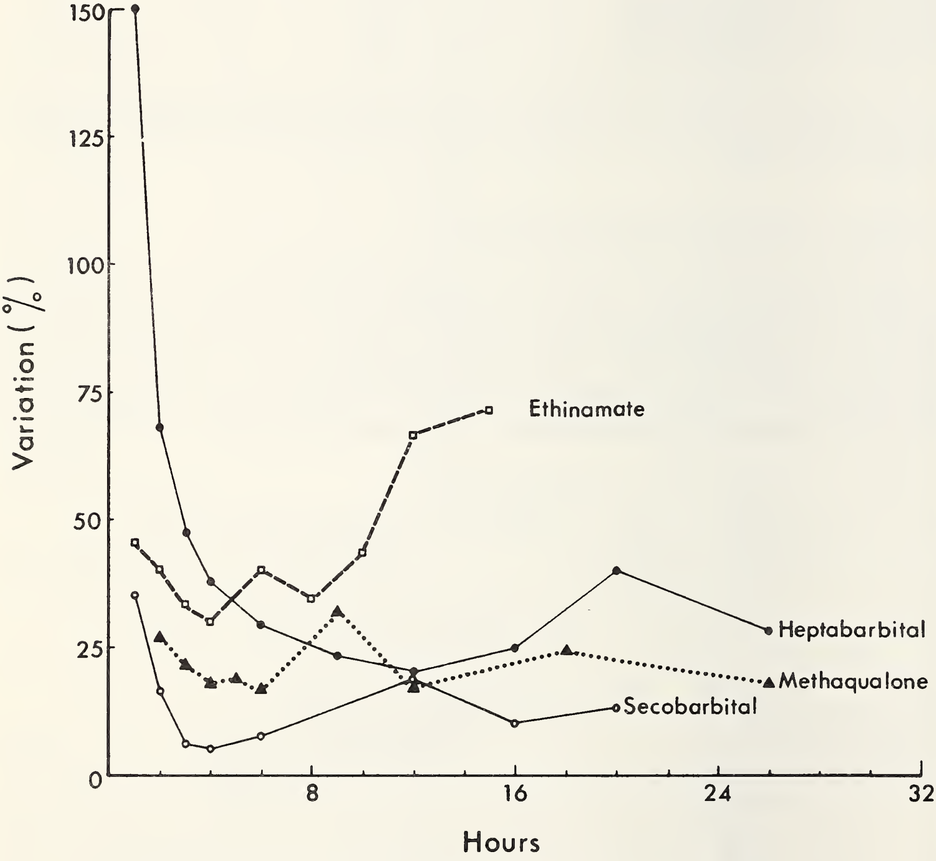


Figure 5 *Percent variation in serum concentrations of ethinamate, heptabarbital, secobarbital and methaqualone. Normal male subjects ingested heptabarbital 6.6 mg/kg, secobarbital 3.3 mg/kg, ethinamate 1g or methaqualone 300 mg just prior to a light breakfast. Peak concentrations occurred at 6 hours (heptabarbital), 3 hours (secobarbital), 1 hour (ethinamate) and 2 hours (methaqualone). Percent variation = standard deviation/mean x 100). Data calculated from reference (9).*

Figure 5 shows the percent variation among subjects in plasma drug concentration during a study of 4 sedative-hypnotics (9). There is marked among-subject and among-drug variation for all drugs studied. Inter-subject variation is highest initially and falls. This initial variation is due to variation in rates of absorption, heptabarbital > ethinamate > secobarbital > methaqualone. Interpretation of studies done of driving skills during the first two hours could be impossibly confounded by the huge inter-subject variations in absorption of these drugs. Even at the nadir of variation the inter-subject variation is 5-30%. Ethinamate and secobarbital indicate increasing inter-subject variation late in the study reflecting important inter-subject variation in rate of biotransformation for these two drugs.

A similar pattern of inter-subject variation in absorption of alcohol is reflected in the variable blood alcohol concentrations resulting after ingestion of 0.8 g/kg in normal subjects and to a lesser extent after 0.5g/kg (Table IV). Among-subject variation in blood alcohol decreases later in the study.

TABLE IV *Percent Variation in Blood Alcohol Concentrations*[a]

Drug	Time After Ingestion (minutes)		
	30	90	150
Alcohol 0.5 g/kg	25	22	26
Alcohol 0.8 g/kg	33	13	19

[a] Data calculated from reference (37). Ten subjects in each alcohol group. Percent variation = standard deviation/mean x 100.

The factors influencing absorption can be complex. One drug can increase or decrease the rate or extent or absorption of another (46). Table V summarizes data suggesting that alcohol increases the rate of absorption of diazepam and chlordiazepoxide (38). Neither the completeness of absorption nor the effect of ethanol on the pattern of benzodiazepine biotransformation were studied. Higher and earlier peak concentrations of these two benzodiazepines occurring after alcohol may be sufficient to explain the interaction of alcohol and benzodiazepines reported by some authors.

TABLE V *Influence of Alcohol on Serum Diazepam and Chlordiazepoxide Concentrations*[a]

Drug	Serum Drug Concentration (ng/ml) Time after Administration (minutes)		
	30	90	150
Diazepam 10 mg	36 ± 17	164 ± 95	119 ± 69
Diazepam + Alcohol	103 ± 93	227 ± 89	285 ± 54
Chlordiazepoxide 25 mg	60 ± 20	320 ± 130	1040 ± 430
Chlordiazepoxide + Alcohol	300 ± 240	1200 ± 810	1680 ± 855

[a] Data from reference (38). Studies conducted in 5 normal subjects in each group. Alcohol dose 0.8 g/kg orally. Results are given as mean ± standard deviation.

TABLE VI *Psychoactive Drugs Exhibiting First-Pass Biotransformation*

Drug	Reference
Chlorpromazine	(26)
Desmethylimipramine	(26)
Morphine	(26)
Nortriptyline	(26)
Opiates?	(6)
Propranolol	(16)
Reserpine	(39)
Tetrahydrocannabinol	(26)

The pH of the stomach and small intestine, alterations in gastric motility or the presence of food can decrease the absorption of drugs to an important extent (31). Another reason very little of some drugs reach the systemic circulation is that extensive biotransformation may occur as the drug first reaches the liver. After oral administration, a number of drugs are extracted from portal blood draining the site of drug absorption in the upper small intestines, and are metabolized in the liver (Table VI and VII). The apparent low bioavailability of some psychoactive drugs reflects this "first-pass" metabolism. After low doses, almost no drug may reach the systemic circulation. At higher doses, since hepatic extraction or rate of biotransformation may be saturable, systemic concentration can increase unexpectedly quickly.

TABLE VII *Bioavailability of Psychoactive Drugs*

Drug	Route	Percent Absorbed	Reference
Chlordiazepoxide	intramuscular	low, variable	(31)
Chlorpromazine	oral	30	(26)
Diazepam	intramuscular	low, variable	(31)
Diphenylhydantoin	intramuscular	low, variable	(31)
Methadone	oral	70	(23)
Nortriptyline	oral	56 - 70	(2)

Protein Binding

The binding of most psychoactive drugs to plasma proteins (usually albumin) is appreciable, and is variable even among 'normal' individuals. The binding of chlorpromazine is 91-99%, (11) diazepam 97.7-99.1% (E. M. Sellers, unpublished observation), desmethylimipramine 87-95% (26), imipramine 87-95% (26) and diphenylhydantoin 78-93% (22).

Liver disease and renal disease have been shown to significantly decrease binding of diphenylhydantoin (22). Protein binding will be decreased by a decreased albumin concentration or competition between drugs for binding sites. The clinical importance of these inter-individual variations in free drug concentration is unknown. Theoretically the effects could be quite profound since the extent of variation, e.g., diazepam 265% is large and the free drug concentration is in equilibrium with site of action, tissue binding sites and sites of biotransformation and excretion.

Assays of drug concentrations measure *total* drug concentration not the free concentration in equilibrium with the site of drug action. There is no study which has attempted to relate free drug concentration to performance on a driving skill.

Tissue Distribution

The steady state concentration (Cp^{ss}) of drugs can be profoundly influenced by the volume of distribution (Equation 1). The V_D for psychoactive drugs may exhibit marked inter-individual variation (Table VIII). Some of this variation may be genetically determined (1) but since these classes of drugs are assumed to be highly lipid soluble, adipose mass can become an important factor governing the half-life and volume of distribution. Increased adipose mass, however, does not importantly alter Cp^{ss} or CL_M (26). Steady state concentration may not change appreciably because both $t_{1/2}$ and V_D increase proportionately (Equation 1). It should be anticipated that obese patients will retain drugs for a longer period of time.

TABLE VIII *Volumes of Drug Distribution*[a]

Drug	V_D (liters)	Reference
Diazepam	11 – 83 (initial)	
	161 – 205 (terminal)	(19)
Nortriptyline	20 – 56	(47)
Chlorpromazine	7 – 80	(39)
Meprobamate	54	(21)
Pentobarbital	134	(48)
Tetrahydrocannabinol	660	(35)
Morphine	700	(6)
Methadone	93 – 300	(24)

[a] See also Table I of reference (26).

Biotransformation

After drug administration, the resulting clinical response can be confused by the appearance of active drug metabolites (Table IX) and drug cumulation.

TABLE IX *Active Metabolites after Oral Administration*

Drug	Reference
Acetylsalicylic Acid	(33)
Amitriptyline	(5)
Amphetamine	(41)
Chloral Hydrate	(45)
Chlordiazepoxide	(19)
Diazepam	(14)
Imipramine	(40)
Methadone	(23, 24)
Phenothiazines	(27)
Δ^9-Tetrahydrocannabinol	(35)

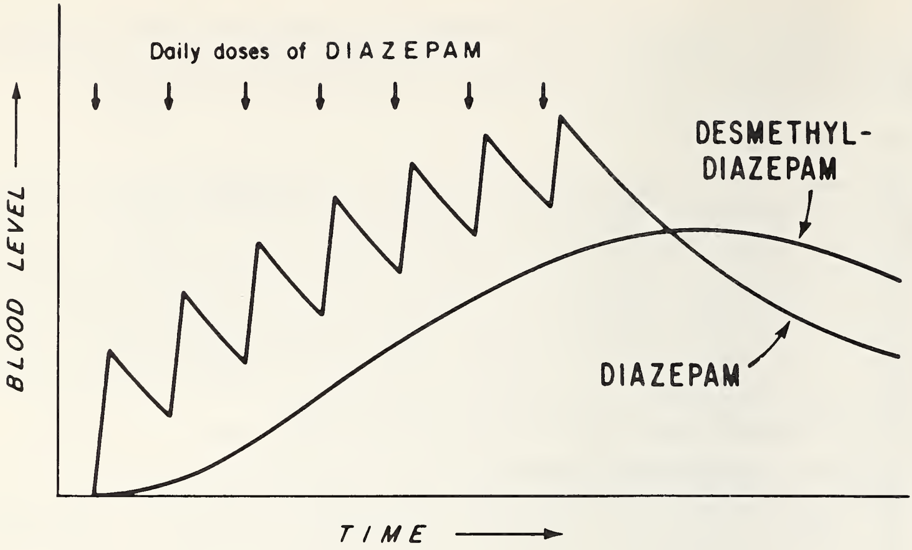


Figure 6 *Blood levels of diazepam and desmethyldiazepam during and after repeated administration of diazepam. After Journal of Pharmaceutical Sciences 62, 1789-1796 (1973), and reproduced with permission of Raven Press, New York, ©1974, reference (19).*

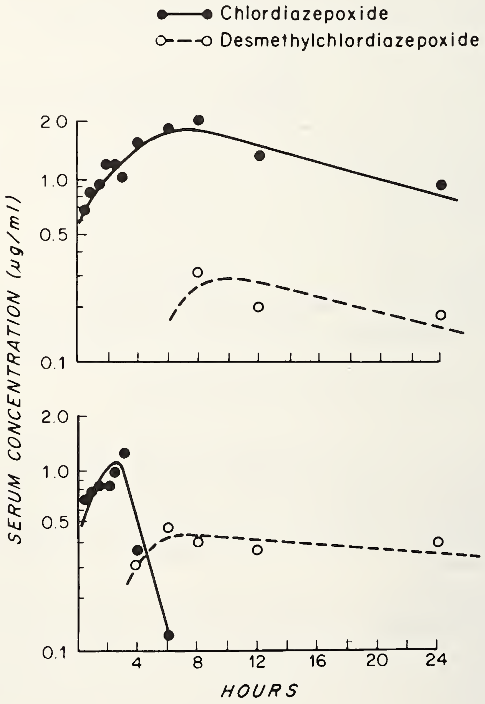


Figure 7 *Serum chlordiazepoxide and desmethylchlordiazepoxide concentrations after identical oral doses to two normal subjects.*

Active metabolites. Repeat administration of a drug results in cumulation of drug in the body (Figure 6). Diazepam is converted in the liver to three pharmacologically active metabolites, desmethyldiazepam, temazepam and oxazepam (19). Figure 6 shows schematically that repeated oral administration of diazepam in man leads to a steady rise in drug concentration in the serum with a plateau reach in 5-7 days. After several days of therapy, desmethyldiazepam, the major metabolite, begins to cumulate. At steady state desmethyldiazepam concentrations may exceed those of diazepam. Upon cessation of therapy, levels of both drugs decline, but desmethyldiazepam, with an apparent half-life of 96 hours in some subjects, will persist in plasma longer than diazepam (19). The metabolism of the minor tranquillizer, chlordiazepoxide, is equally variable. Figure 7 shows examples of slow and rapid biotransformation of chlordiazepoxide in two individuals. It is unlikely and unreasonable to expect identical responses to a standard dose of chlordiazepoxide in these subjects. The metabolite produced is pharmacologically active.

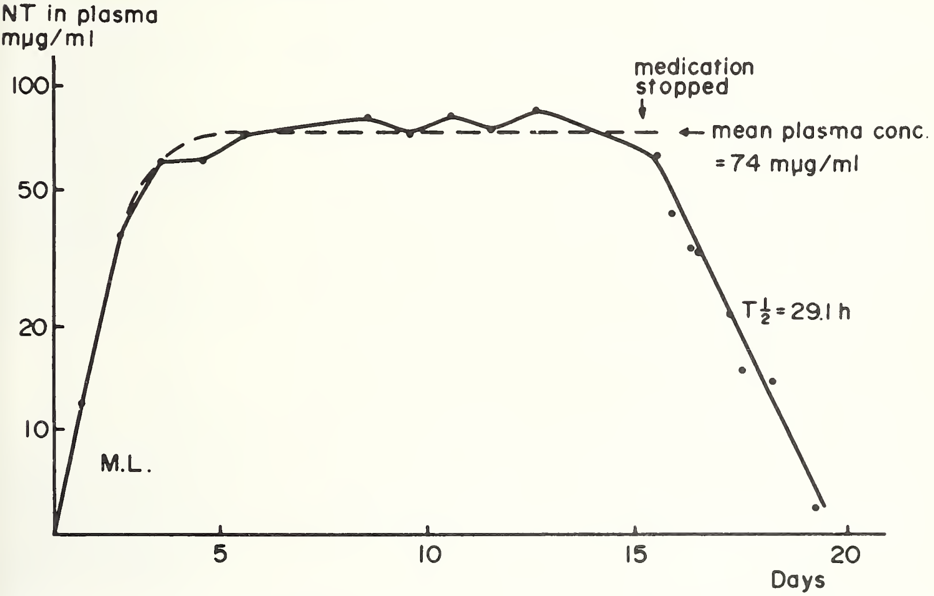


Figure 8 *Cumulation and elimination of nortriptyline. The subject received 0.4 mg three times per day until the medication was stopped (reproduced with permission from reference (1)).*

Cumulation. There is an important need for studies of the chronic effects of drug therapy on driving skills. Such studies pose some unique problems with respect to duration of therapy and interval between studies.

Figure 8 shows the cumulation of nortriptyline, a tricyclic anti-depressant in the blood, during chronic oral dosing with the drug (1). There are three questions to answer. First, since studies presumably should be done at the stable concentrations, is it possible to estimate how long it will take to reach the stable plateau concentration? Second, what is the concentration at steady-state? Finally, how long would it take to eliminate the drug if therapy was stopped? The time to reach a plateau can be estimated reasonably accurately from the half-life (18). Since, theoretically, one hundred per cent cumulation cannot be reached, it is convenient to estimate the time to reach 95%, 99% or 99.9% of the plateau.

Time to reach 95.0% of maximum cumulation:
    4.32 x DRUG HALF-LIFE
Time to reach 99.0% of maximum cumulation:
    6.64 x DRUG HALF-LIFE
Time to reach 99.9% of maximum cumulation:
    9.96 x DRUG HALF-LIFE

TABLE X *Estimated Time for Cumulation of Parent Drug to Steady State Concentrations*[a]

Drug	Time for Cumulation (days)	
	95%	99%
Diazepam	7.1	10.9
Methaqualone	4.3	6.6
Secobarbital	5.2	8.0
Heptabarbital	1.7	2.7
Nortriptyline	4.9	7.6
Imipramine	4.3	6.6
Propoxyphene	4.3	6.6
Chlorpromazine	5.4	8.3
Pentobarbital	7.7	11.9
Diphenylhydantoin	4.0	6.1
Meprobamate	2.1	3.9
Glutethimide	7.2	11.1
Tetrahydrocannabinol	10.1	15.5
Methadone	2.9	4.4
Chlordiazepoxide	4.3	6.6
Oxazepam	2.7	4.1

[a] Calculations are based on mean half-life data and do not account for considerable inter-individual variation in half-lives nor for the appearance and/or cumulation of active or toxic metabolites. The majority of these estimates are not derived from experimental studies of cumulation but rather estimated from knowledge of the terminal $t_{1/2}$. Where experimental data exists there is good agreement between the calculated and observed values. These calculations will also indicate the time required for 95% or 99% elimination of the drug.

These simple calculations also estimate the time for 95%, or 99.9% elimination of a drug.

Table X summarizes for some psychoactive agents the time to achieve 95% and 99% cumulation or elimination. Effects of chronically administered drugs on driving skills must take these cumulation and elimination principles into account in determining the duration of administration before steady-state is reached and, in selecting the no treatment interval between cross-over studies. The same calculations should be applied to any active metabolite nortriptyline. Amitriptyline and its metabolites may be excreted for over a month after a single large dose. (S. M. MacLeod, unpublished results). Situations in which active metabolites are produced, become further complicated since unchanged parent drug stored in the body is acting as a continual source of new substance.

The concentration at steady-state can be calculated if the V_D at steady state and plasma half-life are known (Equation 1). Since both half-life and volume of distribution (Tables I and VIII) vary so considerably among individuals, calculations of this sort are only guidelines and direct determination of drug concentration will provide a more reliable index of time to cumulation and steady-state concentration. Single intravenous doses of drugs may yield reasonable estimates of $t_{1/2}$ and V_D but there are numerous examples where these parameters were not useful predictors for drug cumulation during chronic studies.

Table XI summarizes the ranges of steady-state drug concentrations in subjects on constant drug doses. Not unexpectedly, the variations in steady-state concentrations of parent drug are also reflected in wide variation in the ratio of parent drug/active metabolite, e.g., amitriptyline 0.4-2.5, diazepam 0.6-1.7 and imipramine 0.3-1.6.

TABLE XI *Steady State Serum Drug Concentrations on Fixed Drug Dosages*

Drug	Range (ng/ml)	Reference
Amitriptyline	20 – 195	(5)
Chlorpromazine	10 – 107	(39,42)
Desmethyldiazepam[a]	14 – 776	(4,14,17)
Desmethylimipramine	8 – 290	(40)
Diazepam	264 – 647	(28)
Nortriptyline	10 – 275	(1,26)

[a] Active metabolite of diazepam

TABLE XII *Pharmacokinetics of Benzodiazepines in Humans*[a]

Drug	Half-Life Parent Compound (hours)	Metabolites in Blood[b]
Chlordiazepoxide	7-18	*active* desmethylchlordiazepoxide demoxepam (oxazepam)[c]
Diazepam	1-6 (1st phase) 20-50 (2nd phase)	*active* desmethyldiazepam (major) temazepam (minor) (oxazepam)[c]
Flurazepam	rapid	inactive
Lorazepam	slow > 24	inactive
Nitrazepam	18-28	inactive
Oxazepam	3-21	inactive

[a] Data summarized from reference (19).

[b] Elimination of the active metabolites of chlordiazepoxide and diazepam may be slower than the parent compound, in some patients.

[c] Oxazepam glucuronide appears in the urine.

The benzodiazepines illustrate the kinetic characteristics of many psychoactive drugs (Table XII). Table XIII summarizes the metabolic characteristics of psychoactive drugs.

Elimination

The importance and extent of inter-subject variation in renal or biliary elimination of psychoactive drugs is not known. The excretion of imipramine and amphetamines is markedly decreased in subjects with alkaline urine (15, 26).

TABLE XIII *Properties of Psychoactive Agents*[a]

Physiocochemical	
	High octanol: water partition coefficients; hydrophobic; pKa close to pH 7.4
Metabolic	
	Absorption: variable Serum protein binding: high, variable Biotransformation: complete; active metabolites Excretion: only small amounts parent compound recovered from urine or feces.
Kinetic	
	Plasma half-life: long; variable; Volume of distribution: large; variable; localization in fat steady state plasma concentrations; variable

[a] Notable exceptions are the psychomotor stimulants and anorexigenic agents.

OTHER KINETIC CONSIDERATIONS

Many drugs exhibit a linear relationship between dose and steady-state concentration in blood (Equation 1). Some drugs such as ethanol, salicylate and diphenylhydantoin, however, show increasing saturation of biotransformation pathways as dose is increased. As a consequence, higher doses will be associated with disproportionately higher drug concentrations. Other sources of 'non-linearity' are saturation of active transport systems (e.g., renal tubular transport), protein or tissue binding sites, absorptive capacity or biliary excretion (51). In man, in addition to the three agents mentioned above, evidence exists for non-linearity in the disposition of amobarbital, amphetamine and chlorpromazine. Animal studies suggest that pentobarbital, acetaminophen, isoniazid, diphenhydramine, and thiopental also will have a non-linear relation of dose and concentration (51). The existence of non-linear kinetics plus marked inter-individual variations makes measurement of serum concentrations mandatory in experimental studies and in many therapeutic situations with psychoactive agents.

In contrast to the agents mentioned above, where serum concentrations may be unexpectedly higher, thioridazine unexpectedly shows lower concentrations at higher doses (7). Patients on constant doses of chlorpromazine can show a steady fall in C_p^{ss} with chronic therapy (10).

Time of Serum Drug Concentration Determination

The appropriate time to determine drug concentration will depend on the pharmacokinetic properties of the experimental drug and the purpose of the study. In acute studies (*i.e.*, single drug dose associated with early or frequent testing of a driving skill) samples should be taken as early as 10 minutes after the drug and every 15-20 minutes thereafter for the first two hours. Absorption of some drugs is very rapid. In acute studies, which attempt to relate serum concentration to the time course of acute tolerance, it is generally better to take frequent samples in a few subjects than study larger numbers of subjects. Statements in the literature concerning time of peak action or concentration cannot be accepted unless the variation between subjects with respect to these parameters is known. In studies of the effect of chronic drug administration on driving skills, sufficient time must be allowed for full cumulation of drug. Conversely, the interval between studies must be sufficiently long to allow for at least 99% excretion of parent drug and any active metabolites. Longer intervals would be preferable but will be equally arbitrary. To determine if full cumulation has occurred and if excretion is complete, direct assay for the drug(s) and/or metabolites is advisable. During studies single isolated concentration determinations are usually not helpful, since psychoactive drug effects often depend on the rate of change in concentration (e.g., acute tolerance). Therefore, samples should be taken for the duration of the study at times immediately related to testing.

TABLE XIV *Mechanisms of Psychoactive Drug Interactions*

1. Metabolic
    - *Absorption*
        - – rate
        - – completeness
    - *Distribution*
        - blood flow
        - serum protein binding
        - tissue binding
    - *Biotransformation*
        - hepatic
            - microsomal
                - – induction
                - – inhibition
            - non-microsomal
            - extra-hepatic
    - *Excretion*
        - renal
            - – glomerular
            - – tubular
        - biliary
        - pulmonary

2. Physiologic

3. Receptor or Site of Action

Drug Interactions

Interactions of psychoactive drugs can occur at the receptor or site of action (Table XIV). Alternately, these interactions can have a physiologic or metabolic basis. Metabolic interactions have been extensively described for various therapeutic classes of drugs (29) but are less frequently systematically examined in psychoactive drug studies. The likelihood and importance of metabolic interactions is well established. Alcohol increases the rate of absorption of diazepam and chlordiazepoxide (38). Alcohol alters the absorption of various drugs and accelerates the clearance of drugs from the body (25). Various psychoactive drugs can induce hepatic microsomal drug metabolizing enzymes during chronic therapy and thereby accelerate the removal of other drugs and themselves (25).

Competition for binding sites on serum albumin is an important mechanism of metabolic drug interactions since displacement of one highly bound drug by another increases the free active drug concentration at the site of action resulting in potentiation of drug action (43). Since many psychoactive drugs are highly bound, competition between various drugs and their metabolites will exist. The high volumes of distribution of psychoactive drugs strongly suggests that large and clinically important displacement of these drugs from these 'inactive' tissue sites occurs.

Any detailed study of mechanism of interactions will require the construction of an 'interaction surface'. Such a study examines, at multiple doses for each drug, both the pharmacologic effect and blood concentrations. Figure 9 shows such an interaction surface, constructed in a study of the interaction of meprobamate and alcohol (8).

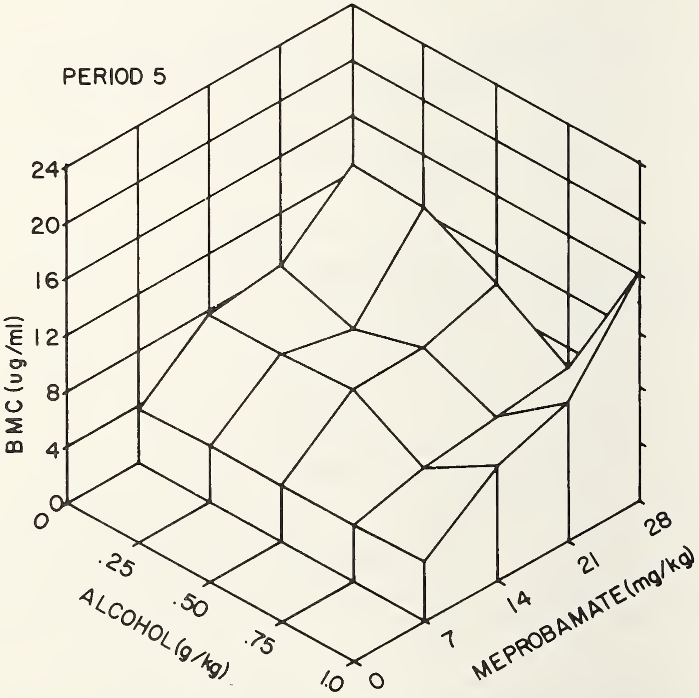


Figure 9 *Drug interaction surface for the metabolic interaction of meprobamate and ethanol (reproduced with permission from reference (8)).*

Shown are five dose levels of alcohol and meprobamate and the resulting blood meprobamate concentrations at a particular time. The peaks and valleys indicate a highly complex interaction mechanism.

Development of Acute Tolerance

Few studies have examined the relation of serum drug concentration and the development of acute tolerance. Such studies seem essential as part of acute and chronic studies for without them there is no way of determining how much inter-individual response is related to the rate of rise of serum drug concentration or to differences in 'end organ' responsiveness and adaptation. Figure 10 indicates the relation of blood alcohol to decrement in performance on a pursuit rotor task in six normal subjects. Subjects also received chloral hydrate and the combination of alcohol and chloral hydrate (44). Trichloroethanol is the major active metabolite of chloral hydrate. The combination of ethanol and chloral hydrate results in a further decrement in performance (associated with higher alcohol and trichloroethanol concentrations than either drug dose alone, *i.e.*, metabolic interaction) and a change in the relationship of concentration and effects. The interaction of chloral hydrate and alcohol is more predictable within individuals than between them. Similar studies have been done with glutethimide (12).

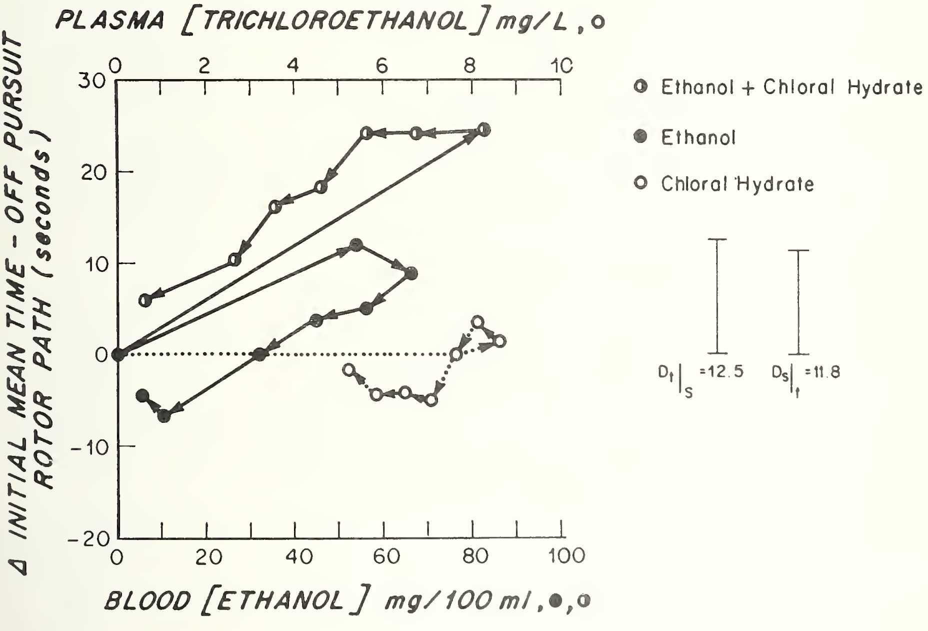


Figure 10 *Interaction of chloral hydrate and ethanol (taken from reference (51)).*

Specificity and Sensitivity of Assays

Numerous erroneous reports in the literature attest to the critical importance of sufficiently sensitive drug assays. Even recently, insensitive assays have led to erroneous determinations of plasma half-life for morphine, methaqualone, various barbiturates, propoxyphene and benzodiazepine (19, 26, 50). In order to predict cumulation and elimination and to formulate rational dosing schedules, it is imperative to be able to determine the *terminal* phase of drug elimination. For most psychoactive agents, even though typically present in only nanogram per milliliter concentrations, fluorometry, gas chromatography, radioquantitation, chemical vapor analysis or mass spectrometry can give entirely adequate sensitivity. Specificity of assays to separate parent compound from active metabolites is also important since active metabolites should be assayed concurrently with parent compound.

CONCLUSION

There is overwhelming evidence in the literature that serum concentrations are better predictors of therapeutic effect or toxicity than dose for many drugs. Examples include aspirin, digoxin, digitoxin, procainamide, quinidine, many antibiotics, theophylline, diphenylhydantoin, lithium, nortriptyline, desmethylimipramine, and phenothiazines (12, 30, 32, 39, 46, 47).

The evidence is best for drugs with easily measurable end points of clinical efficacy, (e.g., antiarrhythmics) and worst with psychotherapeutic agents. Paradoxically, serum concentration measurements will be of greatest use eventually where direct measurement of therapeutic effect or toxicity is most difficult, i.e., psychotherapeutic drugs. The misconception that serum concentration measurements are not helpful is due to our lack of sophistication in measurement of psychoactive drug effects and application of pharmacokinetic analysis. Where sufficient effort has been made, correlations of serum concentrations and effect are better than those established for dose and effect for phenothiazines (10), nordiazepam (29), nortriptyline (25), desipramine (43), and LSD (8) among others. Serum concentration measurements are not perfect indices of the expected pharmacologic effect but are better predictors of effect than dosage alone.

The vast majority of studies of drug effects on driving skills have failed to include concurrent measurements of plasma drug concentrations. The predictable result, because the relation of dose to concentration is so variable, is a literature of confusing, contradictory and often uninterpretable results. Sufficiently sensitive and specific assays for many drugs are now available, and future experimental studies of drug effects on driving skills should include such analysis. The design of future studies should be based on a greater awareness of the metabolic fate and pharmacologic actions of the experimental drugs.

Future directions for studies could include: effects of chronic administration of drugs on driving skills in the patient population under therapy. Drugs of particular importance in this respect include antihistamines, tricyclic antidepressants, phenothiazines, benzodiazepines, propoxyphene, isoniazid and diphenylhydantoin. Studies of common non-psychoactive agents such as antipyretics, antibiotics, birth control pills, cold remedies, oral antidiabetic agents and antiarrhythmics are also needed. Detailed *systematic* studies of the influence of alcohol on the metabolic fate of other drugs are long overdue, as are studies of the extent, importance and etiology of inter-individual variation in drug absorption, distribution, biotransformation, excretion and responses to psychoactive agents. These experimental studies need to be complemented by multi-centre epidemiologic studies of drugs associated with driving accidents.

The widespread, intelligent application and appropriate interpretation of serum concentration measurements of psychoactive drugs in driving skill studies will be difficult and expensive. Scientific fact is the absolute requisite for generating useful statements concerning the influence of drugs on driving. Such reliable information cannot be forthcoming until the extent of variation in disposition of psychoactive drugs in man is recognized and appropriate drug assays included as an integral part of studies of drugs and driving skills.

REFERENCES

1. Alexanderson, B., Sjoqvist, F., Individual Differences in the Pharmacokinetics of Monomethylated Tricyclic Antidepressant; Role of Genetic and Environmental Factors of Clinical Importance. *Annals New York Academy of Sciences* 179, 739-751 (1971).
2. Alexanderson, B., Borga, O., Alvan, G., The Availability of Orally Administered Nortriptyline. *European Journal of Clinical Pharmacology* 5, 181-185 (1973).
3. Alvan, G., Lindgren, J. E., Bogentoft, C. and Ericsson, O., Plasmakinetics of Methaqualone in Man after Single Oral Doses. *European Journal of Clinical Pharmacology* 6, 187-190 (1973).
4. Berlin, A., Siwers, B., Agurell, S., Hiort, A., Sjoqvist, F. and Strom, S., Determination of Bioavailability of Diazepam in Various Formulations from Steady State Plasma Concentration Dates. *Clinical Pharmacology and Therapeutics* 13, 733-744 (1972).
5. Braithwaite, R. A., Goulding, R., Theano, G., Barley, J. and Coppen, A., Plasma Concentrations of Amitriptyline and Clinical Response. *Lancet I*, 1297-1300 (1972).
6. Brunk, S. F. and Delle, M., Morphine Metabolism in Man. *Clinical Pharmacology and Therapeutics* 16, 51-57 (1974).
7. Buyze, G., Egberts, P.F.C., Muusze, R. G. and Poslansky, A. Blood Levels of Thiridazine and Some of its Metabolites in Psychiatric Patients. Psychiatra, Neurologia, Neurochirugia 76: 229-239, 1973.
8. Carpenter, J., Some Methodology Considerations in Research on Joint Action. In *Clinical Pharmacology and Toxicology of Psychoactive Drugs. Proceedings of International Symposia on Alcohol and Drug Research*. Sellers, E. M., (ed.), Addiction Research Foundation (in press).
9. Clifford, J. M., Cookston, J. H. and Wickham, P. E., Absorption and Clearance of Secobarbital, Heptabarbital, Methaqualone and Ethinamate. *Clinical Pharmacology and Therapeutics* 16, 376-389 (1974).
10. Curry, S. H., Davis, J. M., Janowsay, D. S. and Marshall, J.H.C. Factors affecting chlorpromazine plasma levels in psychiatric patients. *Archives of General Psychiatry* 22: 209-215, 1970.
11. Curry, S., Relationship Between Binding to Plasma Protein, Apparent Volume of Distribution and Rate Constants of Disposition and Elimination for Chlorpromazine in Three Species. *Journal of Pharm Pharmacol* 24, 818-819 (1972).
12. Curry, S. H., Concentration-effect Relationships with Major and Minor Tranquillizers. *Clinical Pharmacology* 16 *(Part 2)*, 192-194 (1974).
13. Curry, S. H., Concentration-effect Relationship with Major and Minor Tranquillizers. *Clinical Pharmacology and Therapeutics* 16, 192-197 (1974).
14. Dasberg, H. H., van der Kleijn, E., Guelen, P.J.R.. and Van Praag, H. M., Plasma Concentrations of Diazepam and its Metabolite N-desmethyl Diazepam in Relation to Anxiologic Effect. *Clinical Pharmacology and Therapeutics* 15, 473-483 (1974).
15. Davis, J. M., Kopin, I. J., Lemberger, L., Axelrod, J., Effects of Urinary pH on Amphetamine Metabolism. *Annals New York Academy of Sciences* 179, 493-501 (1971).

16. Evans, G. H. and Shand, D. G., Disposition of propranolol VI: Independent Variation in Steady-state Circulating Drug Concentrations and Half-life as a Result of Plasma Drug Binding in Man. *Clinical Pharmacology and Therapeutics* 14, 494-500 (1973).

17. Garattini, S., Marcucci, F., Morselli, P. L. and Mussini, E., The Significance of Measuring Blood Levels of Benzodiazepines. In *Biological Effects of Drugs in Relation to Their Plasma Concentrations*. Davies, D. S. and Prichard, B.N.C. (eds.), University Park Press, Baltimore, 1973. pp. 211-225.

18. Goldstein, A., Aronow, L. and Kalman, S. M., In *Principles of Drug Action*. Harper and Row, New York, 1969. pp. 292-316.

19. Greenblatt, D. J. and Shader, R. I., *Benzodiazepines in Clinical Practice*. Raven Press, New York, 1974.

20. Hall, R. J. (Ed.), Bibliographic Series, *Drug Use and Driving*, Addiction Research Foundation, 1974.

21. Held, H., and Alderhausen, H.F.V., Zurpharmacokinetic von meprobamate bei Chronishen Hepatopathien und Arzneimittelsucht. *Klinische Wochenschrift* 47, 78-80 (1969).

22. Hooper, W. D., Bochner, F., Eadie, M. J. and Tyrer, J. H., Plasma Protein Binding of Diaphenylhydantoin: Effects of Sex Hormones, Renal and Hepatic Disease. *Clinical Pharmacology and Therapeutics* 15, 276-282 (1974).

23. Inturrisi, E. E. and Verebely, K., Disposition of Methadone in Man after a Single Oral Dose. *Clinical Pharmacology and Therapeutics* 13, 923-930 (1972).

24. Inturrisi, E. E. and Verebely, K., The Levels of Methadone in the Plasma in Methadone Maintenance. *Clinical Pharmacology and Therapeutics* 13, 633-637, (1972).

25. Johnson, G., Modification of Drug Effects after Chronic Ethanol Consumption. In *Clinical Pharmacology and Toxicology of Psychoactive Drugs. Proceedings of International Symposia on Alcohol and Drug Research*. Sellers, E. M. (Ed.), Addiction Research Foundation (in press).

26. Jusko, W. J., Saturation and Distribution Effects in the Pharmacokinetics of Psychoactive drugs. In *Proceedings of International Symposia on Alcohol and Drug Research. Clinical Pharmacology and Toxicology of Psychoactive Drugs*. Sellers, E. M. (Ed.), Addiction Research Foundation (in press).

27. Kaul, P. N., Conway, M. W. and Clark, M. L., Pharmacokinetics of Chlorpromazine Metabolites – a Colossal Problem. In *Phenothiazines and Structurally Related Drugs*. Forrest, I. S., Carr, C. J. and Vsdin, E. (eds.), Raven Press New York, 1974. pp. 391-398.

28. Kleijn, E., Rossumn, J. M., Muskens, S. and Rijntges, N.V.M., Pharmacokinetics of Diazepam in Dogs, Mice and Humans. *Acta Pharmacologica et Toxicologica* 29, 109-127 (1971).

29. Koch-Weser, J. and Sellers, E. M. Drug Interactions with Coumarin Anticoagulants. *New England Journal of Medicine* 285, 487-498, 547-558 (1971).

30. Koch-Weser, J., Serum Drug Concentration a Therapeutic Guide. *New England Journal of Medicine* 287, 227-231 (1972).

31. Koch-Weser, J., Drug Therapy: Bioavailability of Drugs. *New England Journal of Medicine* 291, 233-237 (1974).

32. Levy, G., Gibaldi, M. and Jusko, W. J., Multicompartmental Pharmacokinetic Models and Pharmacologic Effects. *Journal of Pharmacology Sciences* 58: 422-424 (1969).

33. Levy, G. and Tsuchiya, T. Salicylate Accumulation Kinetics in Man. *New England Journal of Medicine* 287, 430-432 (1972).

34. Lemberger, L., Silberstein, S. D., Axelrod, J. and Kopin, I. J., Marihuana: Studies on the Disposition and Metabolism of Delta-9-Tetrahydrocannabinol in Man, *Science* 170, 1320-1322 (1970).

35. Lemberger, L., Tamarkin, N. R., Axelrod, J. and Kopin, I., Delta-9-Tetrahydrocannabinol: Metabolism and Disposition in Long-term Marihuana Smokers. *Science* 173, 72-74 (1971).

36. Linnoila, M., Effects of Antihistamines, Chlormezanone and Alcohol on Psychomotor Skills Related to Driving. *European Journal of Clinical Pharmacology* 5, 247-254 (1973).

37. Linnoila, M. and Mattila, M. J., Drug Interaction on Psychomotor Skills Related to Driving: Diazepam and Alcohol. *European Journal of Clinical Pharmacology* 5, 186-194 (1973).

38. Linnoila, M. and Mattila, M. J., Drug Interactions on Driving Skills as Evaluated by Laboratory Tests and by a Driving Simulator. *Pharmakopsychiatrica* 6, 127-132 (1973).

39. Maass, A. R., Jenkins, B., Shen, Y. and Tannerbaum, P., Studies on absorption, excretion and metabolism of 3H-reserpine in man. *Clinical Pharmacology and Therapeutics* **10**, 366-371 (1969).

40. Moody, J. P., Tait, A. C. and Todrick, A., Plasma Levels of Imipramine and Desmethylimipramine during Therapy. *Brit Journal of Psychiatry* 113, 183-193 (1967).

41. Oates, J. A. and Shand, D. G., Are we Measuring the Right Things? The Role of Active Metabolites. In *Biological Effects of Drugs in Relation to their Plasma Concentrations* Davis, D. S. and Prichard, B.N.C. (eds.), University Park Press, Baltimore, 1973. pp. 97-106.

42. Sakalis, G., Curry, S. H., Mould, G. P. and Lader, M. H., Physiologic and Clinical Effects of Chlorpromazine and Their Relationship to Plasma Level. *Clinical Pharmacology and Therapeutics* 13, 931-946 (1973).

43. Sellers, E. M. Koch-Weser, J., Potentiation of Warfarin-induced Hypoprothrombinemia by Chloral Hydrate. *New England Journal of Medicine* 283, 827-831, (1970).

44. Sellers, E. M., Carr, G. and Bernstein, J. G., et al, Interaction of Chloral Hydrate and Ethanol in Man. II: Hemodynamics and Performance. *Clinical Pharmacology and Therapeutics* 13, 50-58 (1972).

45. Sellers, E. M., Lang, M. and Koch-Weser, J., et al, Interaction of Chloral Hydrate and Ethanol in Man. I: Metabolism. *Clinical Pharmacology Therapeutics* 13, 37-49 (1972).

46. Sellers, E. M., Factors Influencing the Interpretation of Drug Concentrations in Acute Drug Overdose. In *Clinical Pharmacology and Toxicology of Psychoactive Drugs.* Sellers, E. M. (ed.), Addiction Research Foundation (in press).

47. Sjoqvist, F., Alexanderson, B. and Asberg, M., et al, Pharmacokinetics and Biological Effects of Nortriptyline in Man. *Acta Pharmacologica Toxicologica* 29, 255-280 (1971).

48. Smith, R. B., Dittert, L. W., Griffen, W. O. and Doluisio, J. T., Pharmacokinetics of Pentobarbital after Intravenous and Oral Administration. *J. Pharmacokinetics and Biopharmaceutics* 1, 5-16 (1973).

49. Spector, S. and Vessel, E. S., Disposition of Morphine in Man. *Science* 174, 421-422 (1971).

50. Verebely, K. and Inturrisi, C. E., Disposition of Propoxyphene and Norpropoxyphene in Man after a Single Oral Dose. *Clinical Pharmacology and Therapeutics* 15, 302-309 (1973).

51. Wagner, J. A modern view of pharmacokinetics. *Journal of Pharmacokinetics and Biopharmaceutics* 1, 363-401, 1973.

Validity of Driving Simulator Studies for Predicting Drug Effects in Real Driving Situations

Herbert Moskowitz[1,2]

Experimental studies play an important part in establishing the nature and extent of possible impairment of driving-related skills by drugs. However, to perform such experiments by placing subjects in typical traffic situations while under the influence of a drug poses serious safety problems. Therefore, investigators have used two alternate methods to investigate the influence of drugs. One is using driving simulators, in which subjects are not exposed to real traffic hazards; the other is to use real cars in a closed driving course with curtailed traffic.

Driving simulators have generally been chosen in preference to the closed driving course. The disadvantage of the latter technique is that by restricting the environment to provide safety, many sources of stimulation characteristic of actual traffic situations are lost. Since one major reason for traffic accidents is failure to perceive important elements of the environment, an impoverished environment removes opportunities to study the effects of drugs upon perception. The simulator is the technique of choice also because it is more capable of ensuring replication of exactly the same stimulus presentation to all subjects. Finally, instrumentation is easier for simulators than for cars. This is true not only for stimulus presentation and response measurement but for measuring the time between stimulus and response.

SIMULATOR REQUIREMENTS

Given our need for such an instrument, what are the requirements for a simulator which will enable it to be an adequate research tool for the study of drug-driving interactions?

Primarily it requires that demands placed upon the subject include those behavioral elements which are required for driving and which have the potential to be affected by the drug under investigation.

Since researchers desire to investigate a wide variety of drugs and one cannot predict which behavioral elements each drug might affect, a driving simulator is required that contains a representative sample of all the behavioral demands of driving.

---

[1] School of Engineering, University of California at Los Angeles, Los Angeles, California 90024.

[2] This work has been supported by Grant No. AA 251 from the National Institute on Alcohol Abuse and Alcoholism, U.S. Department of Health, Education, and Welfare; and from contracts from the National Highway Traffic Safety Administration, U.S. Department of Transportation.

Thus, to construct such a simulator, it is necessary to analyze driving systematically so as to describe and enumerate all major components of the driving task in their proper proportions. A representative sample of the behavioral items could then be incorporated into a simulator. Finally, to validate the simulator as a test instrument, the performance of subjects in the simulator must be correlated with their performance in typical traffic situations on the road. Unfortunately, no such simulator exists nor is likely to exist for some considerable time.

Difficulties in Constructing the Ideal Simulator

The first difficulty is that driving task analysis has not progressed to the point where one can confidently enumerate all the behavioral demands of driving. In an investigation of the behavior units of importance for driver education, a task force at the Human Resources Research Organization developed an incomplete list with more than 1,500 behavioral items believed important for a wide range of fairly common driving experiences (15). Not only was the list incomplete but their relative importance or their relationship to underlying behavioral skills remains unclear.

Another difficulty in achieving the optimal simulator, even if all that one wishes to incorporate into it could be specified, is the limitations of existing technology. For example, one of the prime sources of information about the driving environment is provided to the driver by the effect of inertial forces upon kinesthetic and vestibular receptors.

Only a few simulators are capable of applying inertial forces to the subject in conjunction with simulation of appropriate vehicle movement on a road. In these moving-base simulators, the cab in which the subject sits rotates, rolls, and yaws. These simulators are used by car manufacturers (for example, General Motors and Volkswagen) interested in the ability of subjects to control vehicles with different handling characteristics. Such a simulator has increased capabilities of reproducing the sensations experienced in cars with different chassis suspensions. However, even these are only capable of momentarily duplicating some of the inertial forces which are experienced in actual driving. Most simulators are incapable of producing any inertial cues.

At this time it appears impossible to build the ideal all-purpose research simulator because we are not able to specify all that it should contain, nor are we technically capable of building into it all that we already know is of importance for driving.

Therefore, it can be concluded that all current simulators sample only a restricted range of the possible behavioral demands met upon the road. This limits the conclusion to be drawn from the presence or absence of any drug-performance interaction found in a given simulator. Thus, if we desire to examine the reliability and validity of drug simulator studies, it is necessary, firstly, to understand the specific behavioral demands of the simulator used and secondly, to compare drug-performance changes in the simulator with the nature of accidents when under the influence of the drug. Unfortunately, there has been no systematic analysis of what various simulators require from the behavior of subjects. They have been constructed to sample behavior either in accordance with the builder's theoretical assumptions (which are rarely explicated), or they have been built to incorporate whatever is available in the technological state of the art in constructing simulators. As a result of the lack of clarity regarding the behavior demands on the subjects in different simulators, the source of variability in results cannot be determined.

TYPES OF SIMULATORS

The above discussion bears on an issue arising from the literature where simulators are dichotomized as either whole - or part-task simulators (24). Whole-task simulators are defined as those in which the driver makes acceleration, braking and steering adjustments appropriate to the changing visual scene. A part-task simulator is presumed to simulate only part of the environment and response demands of actual driving. Such a dichotomy is misleading since no simulator exists which contains a representative set of stimuli sources and response demands of driving. In fact, all are truly only part-task simulators.

The differences in the behaviors sampled by different simulators will be understood if we examine the range of devices which have been used as driving simulators in drug studies. There are both programmed and unprogrammed simulators. A programmed simulator is one in which the driver's reaction to the visual scene has no effect upon that presentation. Such a simulator was used by Crancer, *et al.* to study the effects of marihuana and alcohol (8). Subjects viewed a film and were required to manipulate a steering wheel, brake and accelerator appropriately, but nothing of what they did affected the presentation.

The visual presentation of unprogrammed simulators change in response to the driver's behavior, and they vary considerably in response capability. In the UCLA simulator used to study the effects of alcohol and marihuana, the driver could change speed by manipulation of the accelerator and brake, which in turn controlled the speed of the filmed projection (16, 19). By use of the steering wheel the driver produced a rotation of the film projector resulting in a lateral movement of the visual scene.

Other unprogrammed simulators have even greater ability to respond to the subject's control. These include simulators which utilize television cameras moving over a model road, and point light source simulators which have a shadow projection from a moving model landscape.

The most versatile unprogrammed simulator is one where the subject faces a television screen with a road scene which is generated by computer (11). The computer memory bank allows subjects a choice of different paths at various junctions. Volkswagen has such a simulator in operation.

In general, the versatility of the unprogrammed simulators is bought at the cost of an increasingly sparse presentation of the complex elements of the environment. For example, they often encompass small visual angles in contrast to the wide visual demands of driving. Further, the more elaborate unprogrammed simulators permit the subject to choose his pathway by forsaking the use of filmed presentations. Yet one of the more important issues is the effect of drugs upon the perception of the visual scene. In this respect, films are (so far) the best means of realistically presenting the objects in the environment with sufficient detail to examine the subject's choice of observational behavior. It is desirable to examine the effects of drugs upon the distribution of drivers' attention to playing children, older pedestrians, other cars, and other such variables.

Some Studies

Only sparse visual elements are presented by many simulators used in drug research. For example, the simulator used by Landauer *et al.* to study alcohol and amitriptyline was simply a step type pursuit tracker with five bulbs in a horizontal line (13). The pointer above the bulbs was controlled by a steering wheel which the subject moved to align the pointer with the lit bulb.

Binder, studying marihuana and alcohol, used an array of 96 bulbs in 6 rows and 16 columns (3). On a random basis one bulb was lit and by use of a joy stick subjects tracked to that bulb with a circular light indicator. Both of these studies included requirements for the subject to respond simultaneously to a subsidiary task while performing the primary pursuit tracking task.

These last two studies placed prime emphasis on the tracking task with a simplified visual scene. In contrast, Buikhuisen and Jongman studied the effects of alcohol on performance in a simulator which required no measurable motor response (4). Subjects simply viewed a film presentation and the distribution of their eye movements and fixations were recorded.

The above review suggests that not only is there no simulator which adequately samples the totality of behavioral driving demands, but that the simulators in current use differ greatly so that it is unlikely the behavioral demands upon the subjects are the same.

Therefore, there is no existing simulator in which we can test a subject under the influence of a drug and conclude that if there is no change in performance as compared to placebo condition, there will be no effect upon actual driving.

BEHAVIORAL DEMAND CHARACTERISTICS

No simulator samples all stimulus inputs and demand characteristics of driving. A drug might be potentially detrimental to some behavioral mechanism not required in the simulator. On the positive side, since simulators do sample a restricted sub-set of behaviors, to the extent that we can specify that sub-set, we are in a position to generalize to potential drug effects on that behavioral sub-set in actual road conditions.

It should be noted that speaking of a sub-set of behaviors is not meant as a reference to the specific response measures of the simulator. Drug impairment of a behavioral mechanism such as vigilance could be reflected in performance decrements on many simulator measures from frequency of steering wheel reversals to brake pressure. An example may clarify this last issue. Moskowitz reported two studies on the effects of approximately .10% blood alcohol concentration (BAC) on performance in the UCLA film simulator (16). The subject's responses permit the derivation of 25 performances measures of car control and tracking. It is of interest that in the first study none of the car control and tracking measures showed impairment under the rather high alcohol intake. The study was then replicated with the inclusion of a simple subsidiary task which required the driver to respond appropriately to two colored lights presented at one of two positions on a random basis with a frequency roughly 1 per minute during a 31 mile drive. Under the additional information-processing requirement of the subsidiary task, not only did the alcohol produce impairment in performance of the subsidiary task, but also in 12 of the 25 car control and track measures which formerly demonstrated no alcohol effect.

Thus, "behavioral demand characteristics of a simulator" refers to the character of the psychological demands upon the driver. A drug which affects the ability of a subject to process information from the traffic environment may produce a performance decrement in any or all of a large variety of response measures. In the case just cited, a large group of specific response measures was unaffected by the drug under one condition of psychological demand and significantly affected under other behavioral demand conditions.

Only by specifying precisely what the simulator is testing, that is, what behaviors are required for performance in *that* simulator, can we investigate the validity of those simulator measures for driving performance in the real world.

This view can be illustrated by examination of several issues. 1) Do simulators which share common behavioral elements show similar responses by subjects under the same drug, that is, is performance in driving simulators under drugs reliable? 2) If the performance changes under drugs are reliable and are the same for simulators examining common behaviors, is there a relationship between these changes and performance changes under drugs in actual driving situations; *i.e.*, are the measures valid indices of real world driving?

A review of studies of the effect of alcohol on performance in driving simulators was performed by Heimstra and Struckman (12). They examined 14 studies and classified the effects of alcohol into seven categories of behavior within these studies, namely, tracking, steering wheel reversals, accelerator reversals, brake usage, speed, signaling errors and tasks involving higher mental functions. They concluded that "there appears to be no behavior on which the effects of alcohol have been reported more than once with complete consistency. In many cases, alcohol appears to have had opposite effects on the same behaviors in different investigations." The authors did note, however, that performance deficits occurred under the influence of alcohol in six of the seven studies which included demands for higher mental processes.

CLASSIFICATION OF DRUG EFFECTS ON DRIVING

As suggested earlier, a classification of drug effects based on response output categories is not the most productive method of analysis unless one is examining drugs which are assumed to act primarily on peripheral motor networks. An alternate approach to these simulator and other laboratory studies of the effects of alcohol has utilized categories suggested by Stephens and Michaels (25). They suggested that driving could be initially and broadly categorized into a compensatory tracking task, an environmental search and recognition task, and a joint time-sharing system for performing the two tasks.

Using these categories, Moskowitz noted that most experimental studies of either compensatory tracking or of visual search-and-detection tasks when undertaken in isolation, showed little impairment until beyond a BAC of .20% (17, 18). However, both these task systems showed impairment, often at BACs well below .05% when subjects were required to perform two or more tasks concurrently. Therefore, analysis of drug effects for alcohol at least, requires the specification of the demands for information processing by the subject in that situation. It is apparently the brain's capacity of handling two tasks simultaneously that is most susceptible to alcohol impairment. Which performance task or tasks will exhibit the deficit under the drug is a matter of individual emphasis by the subject.

Another example of the lack of relevance of focus on the specific motor response variable can be seen by examining four studies of compensatory tracking under alcohol (5, 7, 20, 22). In all of these studies, the effect of alcohol upon compensatory tracking by itself was negligible. However, all studies reported significant alcohol effects upon compensatory tracking when the tracking task was to be performed concurrently with another task, or while the subjects were influenced by another stressor, such as anoxia.

Alcohol Effects

If we re-examine simulator studies under alcohol and isolate those where it can be clearly seen that there is a requirement for concurrent performance of several subtasks, as is typically found in driving between tracking and environmental search and perception tasks, then good agreement is found that performance is impaired at low to moderate BACs. Newman and Fletcher found impairment when subjects performed a pursuit tracking task and a subsidiary visual recognition task at .095% BAC (21). Asknes found impairment at .05% BAC in a Link trainer when subjects had to track a course, monitor seven instruments and map their course (1). Loomis and West found impairment at .05% BAC for a combined tracking task with a visual recognition and response task (14). Von Wright and Mikkonen found impairment at approximately .05% BAC for a combined tracking and visual recognition task (26).

In studies by Moskowitz (16), and Chiles and Jennings (5), the presence of the additional tasks were experimentally manipulated and it was shown that the primary tracking tasks were unaffected by alcohol except in the presence of the secondary task. In both of the last two studies it was concluded that "A decrease in the ability of the subject to time-share the performance of tasks requiring the exercise of different psychological functions may be the most important detrimental effect of alcohol . . . ." (5).

It is interesting to note that whenever the subject in the simulator was required to perform a joint tracking task and a subsidiary task, usually of a visual signal detection or recognition nature, the secondary task showed the greatest degree of impairment. This is not because tracking has intrinsically greater resistance to alcohol impairment, but is due to the greater emphasis on the tracking task. Tracking presents a continual demand for attention in contrast to the usually intermittent character of the attention demands for the detection or recognition aspects of driving.

Evaluating Alcohol Studies

We can conclude that there is considerable reliability in the sense of agreement among simulator studies when the emphasis of the analysis is upon the psychological function affected by the drug, rather than upon the response variable in which the particular psychological function is exhibited. Thus, to examine the issue of the validity or relevance of the results in the simulator, one must first isolate the behavioral functions that are being affected by the drugs.

If we accept the foregoing analysis which suggests that the most common alcohol effect found in simulator studies is impairment of the capacity for information processing, especially as required in time-sharing of several concurrent tasks, how can we validate these results from actual road traffic studies? One criterion for validation of the simulator would be data describing the nature of the accidents of persons under the influence of drugs. Unfortunately, there are few such studies. While there are many epidemiological studies showing a correlation between the presence of alcohol and increased probability of accidents and injury, little has been done with on-site accident investigations to determine the causal character of the accidents. There appears to be one such published study with alcohol-related accidents including analysis of road-users' errors (6). In this study of 10 accidents involving the presence of alcohol, six were ascribed to either misperception or failure to look, two to excessive speed, and two to decision errors. All but the two due to speed conform to error classifications likely to have occurred if alcohol interfered with information processing and/or time-sharing tasks. In the simulator studies noted above, when subjects were unable to maintain performance on both tracking and visual search-and-recognition tasks, it was the visual task which suffered the larger performance decrement, agreeing with this study of on-site accident causation.

Perhaps the most direct confirmation of the simulator studies comes from an experimental study of the effects of alcohol on airplane flying (2). The study has considerable value since nearly all the typical behavioral performance demands of flying were present. In this study by Billings, Wick, Gerke and Chase, sixteen subjects took off, instrument-flew and landed a plane under four alcohol treatments, resulting in 0, .04, .08 and .12% BAC. Eight of the subjects were highly experienced professional pilots, while the other eight were fairly experienced non-professionals. Flights took place with a safety co-pilot plus a physician located behind the pilot in order to incapacitate him, if necessary. Although the tracking demands of flying are more difficult than those of driving, the experienced pilots suffered no significant decrement in their tracking ability even at the highest dosage. However, beginning at the lowest dosages they committed procedural errors which were a hazard to flight. At the highest dose level, the safety co-pilot had to take command of the plane 11 times to prevent an imminent accident. The inexperienced pilots exhibited impairment in their tracking skills and accumulated far more procedural errors including taking off with full flaps, flying without lights, taking off with carburetor heat on, turning the wrong way in response to instructions, and flying a landing approach tuned to the wrong frequency. Catastrophic procedural errors included loss of control in flight, turns towards oncoming traffic and landing errors that would involve striking the ground. The authors comment:

> *If we assume that instrument-rated pilots, flying ILS approaches, consider the job of guiding their aircraft to a position from which a visual landing can safely be made as their primary task, then it follows that the other, discrete, procedures involved, while no less essential to safe operations, are relegated to a secondary role. The evidence is clear this is in fact the hierarchy which exists. It is equally clear that as pilots are progressively affected by alcohol, they become progressively less able to cope with the various facets of their task, and it is the secondary tasks which suffer first and most.* (2)

Thus, while there is little validating data from either on-site accident studies or experimental field studies, what there is conforms with conclusions regarding the nature of alcohol impairment drawn from studies done in simulators.

It should be noted that in the preceding discussion, there has been no attempt to assess the quantitative increase in accident probability likely from performance decrement in a simulator. While the advantage of a simulator over other forms of laboratory studies is that it is sampling behaviors known to be of significance to driving, the relative proportions of these behaviors and their difficulty level in a given simulator may be unrepresentative of actual driving. Without that additional information, only qualitative judgments about the role of a drug can be offered.

For example, some studies of tracking functions have used input functions unlikely to be found in driving situations other than under unusual circumstances. While this undoubtedly increases the sensitivity of the tracking measures to the drug influence, it decreases our ability to generalize regarding the drug influence on normal levels of demand for tracking skill.

Marihuana Effects

The second most examined drug in simulators probably is marihuana. Three simulators examined visual detection and recognition (two in conjunction with tracking and car control) while two others examined risk-taking. If one examines the nature of the psychological functions under test in these 5 studies, there is considerable agreement or reliability in regard to the effects of marihuana. The studies of Crancer *et al* (8), Moskowitz *et al* (19), and Rafaelsen *et al* (23) examined attention or perceptual functioning and found impairment by marihuana. The Moskowitz *et al* and Rafaelsen *et al* studies also examined tracking and car control performance and found no impairment. Studies by Dott (9) and Ellingstad *et al* (10), examined risk-taking performance and found no impairment.

Again it should be noted that the agreement is in respect to behavioral functions involved in the drug effect rather than in general agreement across simulators. The simulators differed greatly ranging from those completely programmed (8, 10) to those only partly programmed (9, 19, 23).

Unfortunately, there is no means by which the validity of the results can be assessed since there has been no reported analysis of the types of accidents associated with marihuana use. In fact, there is scant epidemiological data to link driving accidents with the presence of marihuana.

While other drugs have been examined in conjunction with driving simulators, there appears insufficient data to permit determination of simulator reliability, much less validity.

SUMMARY

Driving simulator studies are a form of laboratory examination of the effects of a drug, presumably upon some aspect of driving. In general, as regards the behavioral aspects being examined in specific simulators, the results appear reliable for these functions across simulators. The validation process for simulator studies of drug can only refer to the specific behavioral aspects under study. This requires analysis of the nature of driving accidents under that drug in comparison with the behaviors examined in the simulators. As far as alcohol (the only drug for which such data are available) is concerned, the results of the simulator studies agree on the nature of the impairment in accidents.

These conclusions suggest that simulators are of value in the study of drug-driving interactions. However, such studies require an understanding of the character of the behavioral demands of the specific simulator under examination and of how these behavioral demands are reflected in actual driving situations. Unfortunately, there is no simple manner in which simulators can be used as a general technique to evaluate drug effects on driving.

REFERENCES

1. Asknes, E. G., Effect of Small Dosages of Alcohol Upon Performance in a Link Trainer. *Journal of Aviation Medicine* 25, 680 (1954).
2. Billings, C. E., Wick, R. L., Gerke, R. J. and Chase, R. *The Effects of Alcohol on Pilot Performance During Instrument Flight.* Report FAA-AM-72-4, Federal Aviation Administration, Washington, D.C., 1972.
3. Binder, A., An Experimental Approach to Driver Evaluation Using Alcohol Drinkers and Marihuana Smokers. *Accident Analysis and Prevention* 3, 237 (1971).

4. Buikhuisen, W. and Jongman, R. W. Traffic Perception Under the Influence of Alcohol. *Quarterly Journal of Studies on Alcohol* 33, 800 (1972).

5. Chiles, W. D. and Jennings, A. E. Effects of Alcohol on Complex Performance. *Human Factors* 12, 605 (1970).

6. Clayton, A. B., An Accident-Based Analysis of Road-User Errors. *Journal of Safety Research* 4, 69 (1972).

7. Collins, W. E., Schroeder, J., Gilson, R. D. and Guedry, F. E. Effects of Alcohol Ingestion on Tracking Performance During Angular Acceleration. *Journal of Applied Psychology* **55**, 559 (1971).

8. Crancer, A., Dille, J. M., Delay, J. C., Wallace, J. E. and Haykins, M. D., Comparison of the Effects of Marihuana and Alcohol on Simulated Driving Performance. *Science* **164**, 851 (1969).

9. Dott, A. B., *Effect of Marihuana on Risk Acceptance in a Simulated Passing Task.* Public Health Service Report ICRL-RR-71-3, DHEW Publication No. (HSM) 72-10010, Washington, D.C., 1972.

10. Ellingstad, V. D., McFarling, L. H. and Struckman, D. L., *Alcohol, Marijuana and Risk Taking.* Report DOT-HS-191-2-301, Human Factors Laboratory, University of North Dakota, Vermillion, North Dakota, 1973.

11. Gilliland, M. G., Applications of Computer-Generated Imagery to Driver Training Highway Research and Design. In *Simulation, Its Role in Driver Research and Highway Design*, Waller, P. F., (Ed.), North Carolina Symposium on Highway Safety, Chapel Hill, N.C., 1973.

12. Heimstra, N. and Struckman, D., *The Effects of Alcohol on Performance in Driving Simulators.* Paper presented at the OCED Conference on Alcohol and Traffic Safety, Washington, D.C., June 1972.

13. Landauer, A. A., Milner, G. and Patman, J., Alcohol and Amitriptyline Effects on Skills Related to Driving Behaviour. *Science* 163, 1467 (1969).

14. Loomis, T. A. and West, T. C., The Influence of Alcohol on Automobile Driving Ability. *Quarterly Journal of Studies on Alcohol* 19, 30 (1958).

15. McKnight, A. J. and Adams, B. B., *Driver Education Task Analysis, Volume I, Task Descriptions.* Human Resources Organization, Alexandria, Virginia, 1970.

16. Moskowitz, H., *The Effects of Alcohol on Performance in a Driving Simulator of Alcoholics and Social Drinkers.* Report ENG-7205, Institute of Transportation and Traffic Engineering, UCLA, Los Angeles, California, 1971.

17. Moskowitz, H., Laboratory Studies of the Effects of Alcohol on Some Variables Related to Driving. *Journal of Safety Research* 5, 185 (1973).

18. Moskowitz, H., A Behavioral Mechanism of Alcohol-Related Accidents. In *Proceedings of the First Annual Alcoholism Conference of the National Institute on Alcohol Abuse and Alcoholism.* Chafetz, M. E. (Ed.), U.S. Department of Health, Education and Welfare, Washington, D.C., 1973.

19. Moskowitz, H., McGlothlin, W. and Hulbert, S., *The Effect of Marihuana Dosage on Driver Performance.* Report ENG-7341, Institute of Transportation and Traffic Engineering, UCLA, Los Angeles, California, 1973.

20. Newman, H. W., The Effect of Altitude on Alcohol Tolerance. *Quarterly Journal of Studies on Alcohol* 10, 398 (1949).

21. Newman, H. and Fletcher, E., The Effect of Alcohol on Driving. *Journal of the American Medical Association* **115**, 1600 (1940).

22. Pearson, R. G., Alcohol-Hypoxia Effects Upon Operator Tracking, Monitoring, and Reaction Time. *Aerospace Medicine* 39, 303 (1968).

23. Rafaelsen, O. L., Bech, P., Christiansen, J., Christrup, H., Nyboe, H. J. and Rafaelsen, L., Cannabis and Alcohol: Effects on Simulated Car Driving. *Science* 179, 920 (1973).

24. Schori, T. R., Driving Simulation: An Overview. *Behavioral Research in Highway Safety* 1, 236 (1970).

25. Stephens, B. W. and Michaels, R. M., Time Sharing Between Compensatory Tracking and Search-and-Recognition Tasks. *Highway Research Record* 55, 1 (1963).

26. Von Wright, J. M. and Mikkonen, V., The Influence of Alcohol on the Detection of Light Signals in Different Parts of the Visual Field. *Scandinavian Journal of Psychology* 11, 167 (1970).

Effects of Alcohol on Visual Accommodation and Eye Movement Latency

J. Levett[1], L. Karras, and G. Hoeft

It is generally agreed that the ingestion of ethyl alcohol dulls the physiological and mental responses of the human body, that is, alcohol affects the central nervous system and the peripheral nervous system of the body (2). This diminution of responses is caused by alcohol's capacity to impair the impulse conduction and transmission in excitable cells of the nervous system (13). Based on the above evidence, two components of the visual system, accommodation and horizontal saccadic eye movement, were examined, using several subjects with various blood alcohol concentrations.

In order for vision to be clear, a sharp image must fall upon the retina. This is accomplished by a feedback control system in the accommodation process. In driving, as in reading, the predominant eye movement is the horizontal saccade (10). If the response time of both the eye movement and accommodation is affected by alcohol then it may be postulated that serious consequences can result while driving under the influence of alcohol. The intention of this study was to examine the effects of alcohol on these visual tasks and to discuss what influence this alcohol-impaired vision has in the driving situation.

METHODS AND PROCEDURE

The apparatus used to measure the monocular accommodation response time was the triple-function ocular monitor described in (9) which uses infrared techniques. Visual cues instructed the subject to accommodate two diopters from a far target to a near target and conversely, from a near target to a far target. The far target was 20 feet from the eye and the near target was 18 inches from the eye. The visual cue was recorded on a time reference axis, thus providing a time reference of applied accommodation stimulus in which to measure the accommodation response time of the lens. The subsequent lens accommodation from the far target to the near target will be referred to as positive accommodation, and conversely the lens accommodation from the near target to the far target will be referred to as negative accommodation.

The accommodation parameters that were specifically measured are the latency response time and the total accommodation time. The latency response time is the time necessary for the lens of the eye to start to accommodate after the accommoda-

---

[1] Department of Biomedical Engineering, Rush-Presbyterian-St. Luke's Medical Centre, 1753 West Congress Parkway, Chicago, Illinois, 60612, U.S.A.

tion stimulus had been applied. Total accommodation time is the time needed for the lens to accommodate fully after the application of the accommodation stimulus. Accommodation parameters with and without alcohol influence were measured in a darkened environment. No food was taken three hours prior to the experiment and no food was allowed during the experiment. The subject was then given an alcoholic beverage to drink at his own rate for one hour. A rest period of one hour followed the drinking hour. The rest period was necessary to insure collection of data during the body's alcohol elimination phase. In this phase, subjects would maintain a level of blood alcohol long enough to collect data, since the alcohol elimination rate is 15 mg/100 ml/hour (13). The absorption phase has an alcohol uptake rate of approximately 15 mg/100 ml/5 minutes (8) under the fasting conditions of this experiment. This absorption rate would make collection of accommodation data for a blood alcohol level during the absorption phase impossible. All data for each subject were collected in one session. After the rest period the blood level was obtained by analyzing a sample of the subject's alveolar air with an instrument that correlated breath alcohol level with the actual blood alcohol concentration. The instrument used to make this correlation was an Intoxilyzer (6, 7). Twenty-five positive accommodations and 25 negative accommodations were obtained from each of three subjects prior to ingestion of alcohol. The average of these negative and positive accommodation response times was used as a control. Twenty-five negative and positive accommodation response times were subsequently measured for each determined blood alcohol concentration of the subject. The range of blood alcohol concentrations for the accommodation experiments was from 50 to 100 mg/100 ml. The average of these negative and positive responses was determined for each measured blood alcohol concentration and compared with the controls.

In the measurement of eye movement latency, a projector constructed from a low-power helium-neon laser was used to display a stimulus. The laser projected a spot of red light of about 1/4-inch diameter on a white wall from a distance of three feet. This projected spot served as the initial fixation point of the step stimulus. In order to produce a step input to the subject the laser beam was interrupted by a mirror attached to a relay and reflected to a second mirror attached to a modified meter movement which was used as a mirror galvanometer. The reflection of the laser beam from the mirror galvanometer served as the second fixation point of the step input. The amplitude of the step stimulus target movement was controlled by the mirror galvanometer. The horizontal movement of the target was one foot in this experiment.

An eye movement detector was constructed from a pair of eyeglass frames and photo transistors (11). A small infrared light source also mounted on the eyeglass frame was used to illuminate the iris. Eye movement would then be detected when the differential voltage between the photo transistors varied.

Subjects were seated on an ophthalmic examination chair ten feet from a white wall where the stimulus target was located. The one-foot movement of the stimulus dot induced a horizontal-tracking saccadic eye movement of about six degrees. The saccade was then detected by the eye movement detector and processed on-line by a Model 7100 Nuclear-Chicago data retrieval computer which had been triggered by the onset of the stimulus. The computer was operated in the time histogram mode. In this mode of operation a time base record of the occurrence of a saccadic eye movement was made in the form of a histogram for each blood alcohol level. Several eye movement histograms consisting of 25 responses each were completed and used as controls. All eye movement latency measurements were made in a darkened environment.

After the controls were obtained, the subject, who had been fasting for at least three hours, was then asked to drink a quantity of 190-proof ethyl alcohol mixed with an equal volume of lime juice. The amount of alcohol given to the subject was usually enough to obtain a blood alcohol concentration of 100 mg/100 ml. The subject was asked to drink the grain alcohol mixture in as short a time as possible (less than ten minutes). The time at which the drink was finished was defined as the elapsed time T = 0. At T = 15 minutes, a breath test was taken on the Intoxilyzer (6, 7) to determine the blood alcohol level. Within two minutes after the breath test an eye movement histogram of 25 responses was made. Breath tests and eye movement histograms were made every 15 minutes for a period of three to four hours. Blood alcohol concentrations for the eye movement latency ranged from 30 to 140 mg/100 ml. The histograms of eye movement latency consisted of responses elicited from 25 stimuli. Average control (no blood alcohol level) eye movement latency was then compared with average eye movement latency at different levels of blood alcohol concentration.

It should be noted that visual accommodation and eye movement latency experiments were not conducted concurrently and in each experiment subjects were allowed to dark-adapt for 30 minutes.

RESULTS AND DISCUSSION

The results of the monocular accommodation experiments for two diopters of accommodation for each subject at various blood alcohol levels are given in Table I and Figure I.

TABLE I *Tabulated Results of Accommodation Parameters Affected by Alcohol*

	Subject MPM Age 21				Subject FKP Age 33				Subject PF Age 30			
BAC (mg/100ml)	Negative Accommodate		Positive Accommodate		Negative Accommodate		Positive Accommodate		Negative Accommodate		Positive Accommodate	
	A	B	A	B	A	B	A	B	A	B	A	B
CONTROL	.38	.91	.38	.90	.38	.93	.39	.89	.40	1.00	.41	1.02
50	.46	1.04	.45	1.00	.45	1.10	.44	1.12	.53	1.15	.50	1.18
60	.50	1.03	.49	1.01	.42	1.08	.45	1.15	.51	1.16	.53	1.14
70	.49	1.05	.49	1.00	.45	1.10	.50	1.20	.55	1.13	.52	1.20
80	.52	1.12	.50	1.03	.44	1.15	.47	1.22	–	–	–	–
90	.53	1.16	.47	1.06	–	–	–	–	–	–	–	–
100	.51	1.30	.49	1.13	–	–	–	–	–	–	–	–

A = Latency Response Time (SEC)
B = Total Accommodation Time (SEC)

The numerical results in Table I are averages of 25 samples for the particular blood alcohol level and mode of accommodation listed. The deviation around these averages was ± 10 per cent. The average value of the latencies obtained in this experiment for both the negative and positive accommodation controls corresponds closely to the results obtained by Campbell and Westheimer (3). They found that for a step function stimulus, latency for positive and negative accommodation was .38 seconds and .36 seconds respectively.

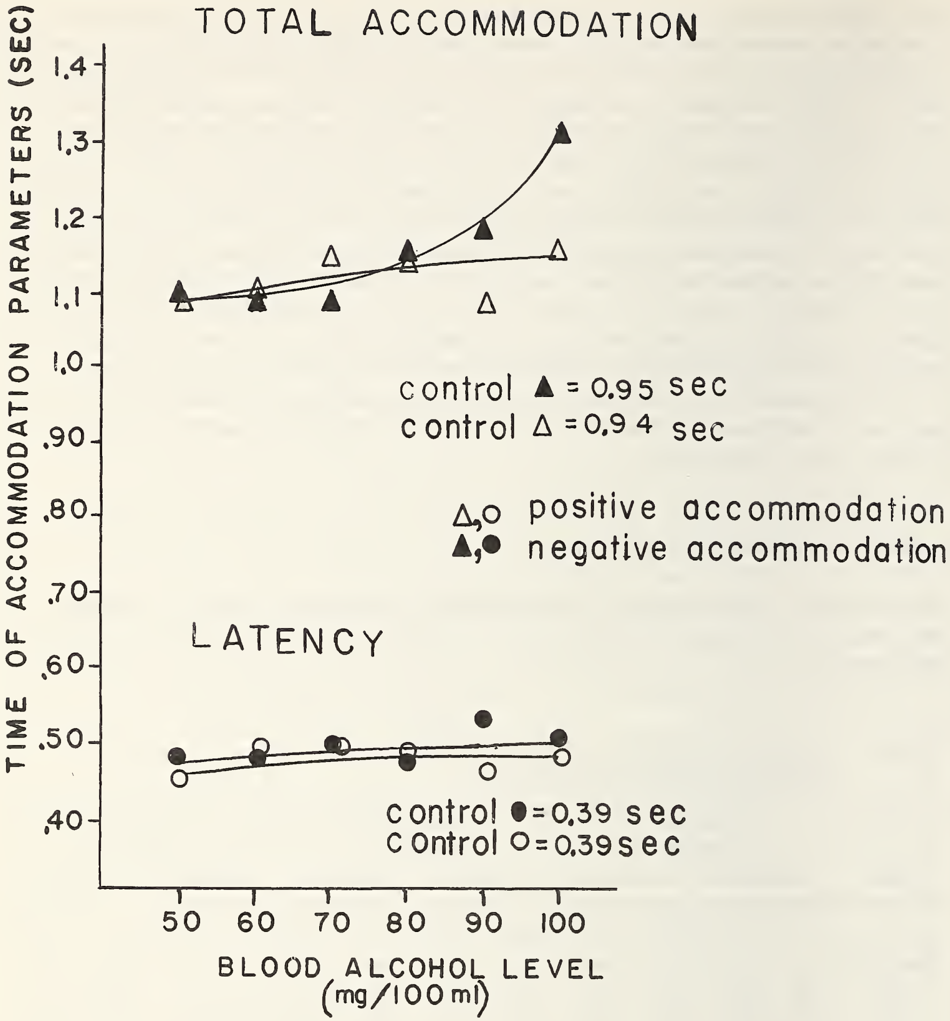


Figure 1 *Average latency and total accommodation response times of all subjects indicated in Table 1 as a function of blood alcohol levels.*

It has been suggested that the time required for positive accommodation may be increased by 0.10 to 0.20 seconds for blood alcohol concentrations of 60 mg/100 ml (2). The data in Table I show that both positive and negative total accommodations of two diopters are retarded for ranges of blood alcohol levels of 50 mg of ethanol/100 ml of blood to 100 mg/100 ml by 0.10 to 0.39 seconds. Latency response time in this range was retarded by .04 to .15 seconds. In general, the accommodation responses under the influence of alcohol are slower than the controls by a factor of 10-40 per cent. Figure 1 indicates that the degree of retardation of the accommodation process increases as a function of the blood alcohol concentration.

In a neurological sense, accommodation is controlled by both the parasympathetic and sympathetic divisions of the autonomic nervous system (4, 12). Stimulation of the sympathetic division and inhibition of the parasympathetic will induce negative accommodation; and likewise, stimulation of the parasympathetic division and inhibition of the sympathetic division will induce positive accommodation. Table I shows that two of the subjects' negative accommodation was more affected by alcohol than positive accommodation. The converse is true for the third subject. One could only conclude from this the need for further study to determine what (if any) differential effects alcohol has on the neurological control division of the accommodation process.

A limiting factor in the accommodation experiments has been the observance of alcohol gaze nystagmus (AGN). Aschan (1) observed that the average blood alcohol level of individuals developing AGN was 60 mg/100 ml and that the threshold range for developing AGN was 30 mg/100 ml to 90 mg/100 ml. He also found AGN to be intensified in a monocular situation. It has been observed in our experiments that two of our subjects developed AGN when their blood alcohol reached levels of 100 mg/100 ml. The data then contained an amplitude of AGN which swamped the accommodation signal completely and further measurement was not attempted. Thus, it appears that a blood alcohol level sufficient to trigger AGN constitutes a threshold beyond which successful experimentation is no longer possible.

Figure 2 shows the elapsed-time-based plot of the mean saccadic eye movement latency values (of five subjects) with the associated ± 95 per cent confidence limits of the plotted mean value. Also indicated on the plots are the corresponding blood alcohol levels determined by breath analysis. The latency data point at N (indicated on the time axis) is the normal non-alcohol mean latency of the subject. The first few data points on the plots have no associated blood alcohol values because a minimum of 15 minutes must pass after ingesting alcohol before a breath sample can be taken, otherwise high blood alcohol readings will result due to residual alcohol in the mouth. It should be noted that AGN did not dominate the eye movement data when it occurred.

As shown in Table II, the overall mean value for the control responses was .248 seconds with an upper 95 per cent confidence limit of .262 seconds and a lower 95 per cent confidence limit of .234 seconds. The mean value of eye movement latencies that occurred at the maximum blood alcohol levels was .314 seconds. When compared with the mean normal value (.248 seconds) a 26 per cent increase in latency is seen.

TABLE II *Summary of Experimental Data and Results Pertaining to Eye Movement Latency.*

					Maximum BAC			Maximum Latency			
Subject	WHT (Lbs)	Quant 190 PF Alcohol (Oz)	AVG Normal Latency (Sec)	MAX BAC (mg/ 100ml)	Latency (Sec)	Laten INCR (%)	Elapsed Time (Min)	Max Laten (Sec)	BAC (mg/ 100ml)	Laten INCR (%)	Elapsed Time (Min)
DB	115	2	.283	100	.340	20	60	.379	90	34	90
GG	140	2.5	.228	140	.324	42	120	.339	130	48	105
TS	170	3	.236	110	.244	3	90	.285	60	20	15
LK	170	3	.313	130	.406	30	30	.406	130	30	30
MB	160	3	.265	120	.304	15	60	.321	110	21	45
Average	–	–	.259	108	.314	21	70	.333	95	28	57
Avg. w/ Normal Study	–	–	.248	–	.314	26	–	.333	–	34	–

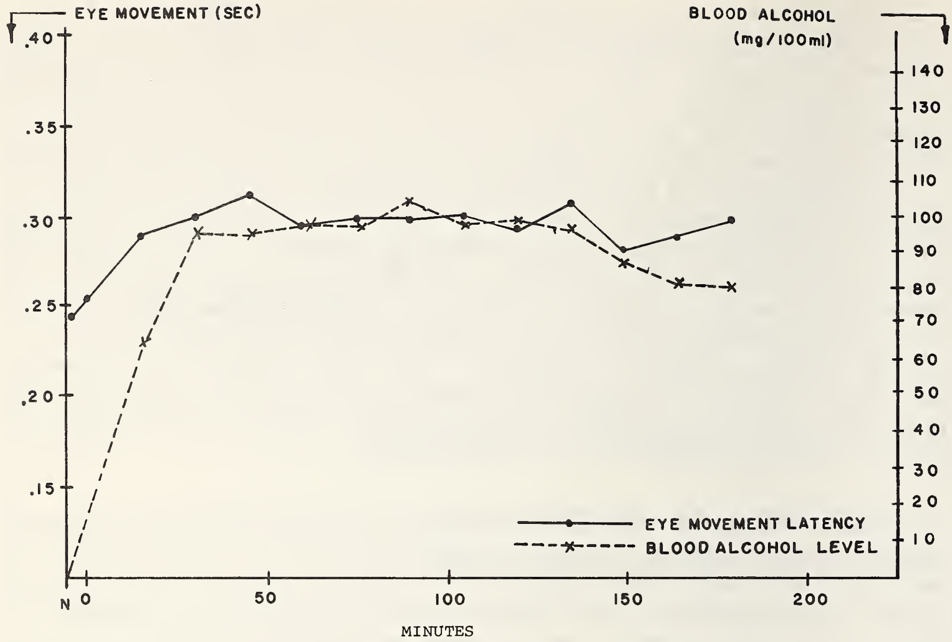


Figure 2 *Composite of five recording sessions (Table II) showing the mean eye movement latency values and blood alcohol levels by elapsed time.*

The maximum latency increase occurred, in most cases, at elapsed times different from those associated with maximum blood alcohol levels. When the average maximum latency (.333 seconds) is compared with the mean normal value (.248 seconds) a 34 per cent increase in the horizontal eye movement latency is seen.

Although the eye movement latency increased with the ingestion of alcohol, it appears that eye movement latency does not increase proportionally with the blood alcohol concentration except during the absorption phase of alcohol. Table II and Figure 2 clearly indicate this and suggest that perhaps there is a saturation threshold of blood alcohol concentration above which eye movement latency is the same. Further studies are needed to determine if such a saturation threshold exists. Figure 2 indicates that eye movement latency reaches a saturation level in the range of 80 to 100 mg/100 ml. Because the principle eye movement made in the operation of a motor vehicle is the horizontal saccade (10) and because the system of accommodation is responsible for a clear image on the retina, the ability to drive safely is seriously compromised by the use of beverage alcohol, according to these data.

Studies have been conducted to determine how much time the visual task components (eye movements and accommodation) require in order to shift one's sight from a far point such as the road to the dash board and back to the far point (5). These studies showed that positive and negative accommodation required the greater part (40%) of the driver's time (.5 seconds to .8 seconds) when shifting sight from the highway to the dashboard to the highway, whereas the eye movement task required about 225 msec or about 15% of the sight-shifting task. Results from our experiments showed an increased eye movement latency up to 100 msec and an increased accommodation response time up to 400 msec at the 100 mg/100 ml blood alcohol concentration in a darkened environment. This would lengthen the round-trip time of eye movement and accommodation when shifting vision from far to near to far by a full second, meaning that the driver would travel (at 60 mph) an extra 88 feet, in addition to the normal 176 feet, without a clear and concentrated view of the road.

Needless to say, effects of alcohol on the visual system, along with the effects of alcohol on the muscular response time and personal psychology at high velocities of travel become crucial to highway safety, especially when ambient highway and weather conditions greatly reduce visibility. These results are of particular interest when it is considered that 30,000 vehicular deaths per year are alcohol-related.

REFERENCES

1. Aschan, F., Different Types of Alcohol Nystagmus, *Acta Otalrynol.* Suppl. 140, 69 (1957).
2. American Medical Association, Committee on Medicolegal Problems, *Alcohol and The Impaired Driver*, Chicago, 1968.
3. Campbell, F. W. and Westheimer, F., Dynamics of Accommodation Response of The Human Eye, *Journal of Physiology (London)* 151, 285 (1960).
4. Cogan, D. G., Accommodation and the Autonomic Nervous System, *Archives of Ophthalmology* 81, 4, 779 (1937).
5. Connolly, P. L., Vision, Man, Vehicle and Highway, in *The Prevention of Highway Injury*, Ed. by Selzer, M. L., Gikas, P. W. and Huelke, D. F., Highway Safety Research Institutes, University of Michigan, Ann Arbor, 1967.
6. Harte, R. A., An Instrument for the Determination of Ethanol in Breath in Law Enforcement Practice, *Journal of Forensic Sciences* 16, 167 (1971).
7. Jain, M. C. and Cravey, R. H., Analysis of Alcohol, I.A. Review of Chemical and Infrared Method, *Journal of Chromatographic Science* 10, 257 (1972).
8. Levett, J. and Karras, L., Implied Consent and Scientific Instrumentation to Make it Work, *Lex Et Scientia* 9, 885 (1973).
9. O'Neill W. D. and Stark, L., Triple-Function Ocular Monitor, *Journal of the Optical Society of America* 58, 570 (1968).
10. Roberts, H. S., *The Causes, Ecology and Prevention of Traffic Accidents.* Charles Thomas, Springfield, Illinois, 1971.
11. Stark, L. and Sandberg, A., A Simple Instrument for Measuring Eye Movements: Quarterly Progress Report, Research Laboratory of Electronics, M.I.T. Movements. *American Journal of Medicine Elect.* 2, 300 (1963).
12. Toates, F. M., Accommodation Function of the Human Eye, *Physiological Review* 52, 828 (1972).
13. Wallgren, J. and Barry III, H., *Actions of Alcohol*, Vol. *I*, Elsevier, New York, 1970.

Effects of Small Doses of Alcohol on the Eye Movements of Drivers

Minoru Kobayashi[1]

Numerous studies concerned with drinking-driving have indicated that degradation of the visual functions is a critical problem. Some typical symptoms are longer eye fixation time, tunnel vision and lack of attention switching mechanism (4). Unfortunately, in most cases, drivers are not conscious that such degradation has occurred.

The major concern of the research reported here was to find out whether such visual deterioration could occur under a blood alcohol concentration (BAC) as low as 50 mg/100 ml, using a test course which provided a similar situation to real driving. Most of the previous studies concerned higher BACs.

PROCEDURE

The experiments were conducted at a driving training track with curved and straight courses where a dummy ejection system was installed (Figure 1). The dummy was clothed and of human size and was usually obscured from the driver's view. It could be ejected by the signal of a photo-cell set off by the passing test-vehicle with different timing set by the experimenter. In this study the ejection system was operated when the car reached a distance of 14 or 22 meters from the dummy. Two skilled drivers, and two non-skilled male drivers who received their driving licences less than three months before the experiment were selected as test subjects. They were instructed to drive the car along the predetermined routes at a speed they considered safe (actual driving speed was between 30 and 50 km per hour). Also, they were informed as to the possibility of the dummy's appearance but not as to its whereabouts. To avoid collision with the dummy, drivers were instructed to make certain avoidance manoeuvres such as turning wheels or hitting brakes.

Nack Eye-Mark Recorder Model II was used to collect eye movement data. On completion of the first and second trials under the non-alcohol condition, the subjects were given whisky at the rate of 2 cc per kg of bodyweight, consumed within 15 minutes (for a 60 kg man this is approximately a 35 g total dose of alcohol). Water and some food were also given. Thirty minutes after completion of drinking, subjects were asked to drive the course again with the same procedure as used in the previous trials.

---

[1] National Research Institute of Police Science, 6 Sambancho, Chiyodauk, Tokyo, Japan 120.

Consumption of such amounts of whisky was expected to produce a BAC of 50 mg/100 ml at the time of the third trial.

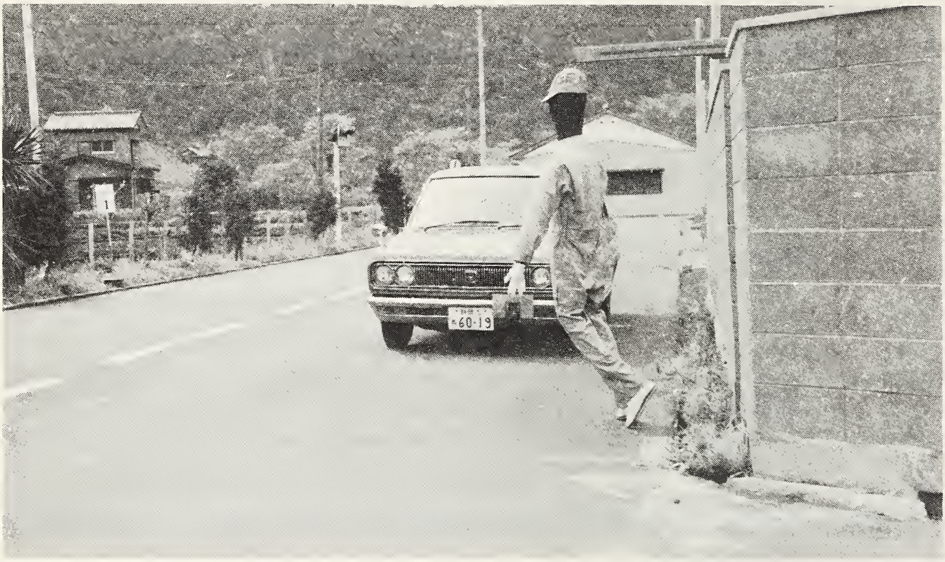


Figure 1 *Dummy ejection system.*

RESULTS

Due to the difficulty in reading recorded eye marks, complete data were obtained only on two of the four subjects. Results of the recognition time study indicate behavior characteristic of unexpected situations. In this experiment, delayed recognition of the dummy was defined as fixation delay to dummy which could be picked up by eye marker spots. As shown in Table I, recognition time to dummy for the first trial was 1.41 seconds for non-skilled and 0.73 seconds for skilled drivers. With the accumulation of trials, recognition time became faster and in some cases a driver fixated to the position prior to dummy appearance which is indicated by a minus mark in Table I. Particularly, recognition time for the non-skilled driver tended to become faster while he was driving under the influence of alcohol (3rd and 4th trial). The sequential process of eye movements for the skilled driver when the dummy came out are shown in Figure 2. Although delay of eye fixation to the dummy became short even under the drinking-driving condition, rapid eye movements (saccadic movements) which are usually seen with non-alcohol driving were drastically diminished. Results also show that fixations as long as 2.50 seconds at one time were obtained.

Generally, eye movements can be classified roughly as fixation and saccadic movements (6). The significant effects on the direction of saccadic movements by alcohol were examined. The data were analysed using the following procedure: x and y values in the co-ordinates in each film frame were measured by graph-pen and were fed into a mini-computer; then the directional frequencies of eye movements were characterised. Figure 3 shows the results for both non-alcohol and alcohol driving conditions.

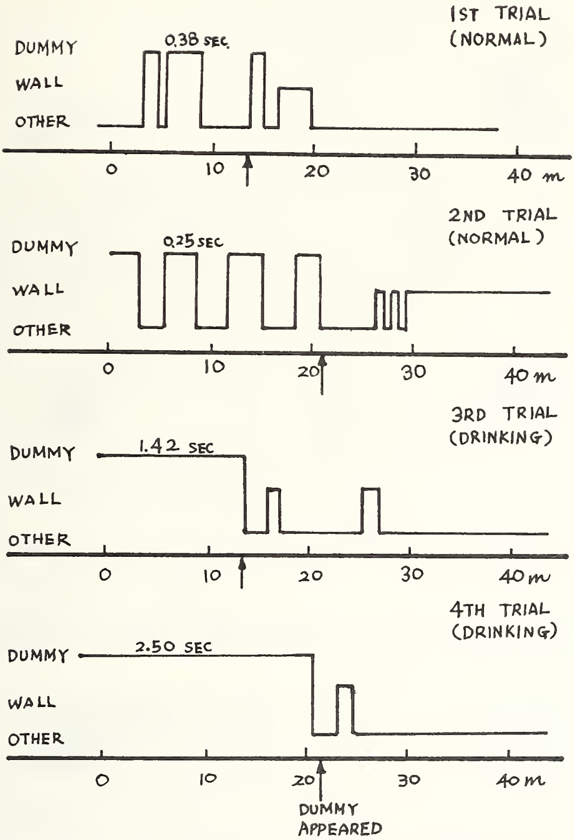


Figure 2 *Fixation patterns for a skilled driver before and after appearance of the dummy. Scale indicates distance of car from dummy in metres; and car movement is from right to left.*

For both skilled and non-skilled drivers under the influence of alcohol, saccadic vertical (up and down) eye movements were increased and, by contrast, horizontal (left and right) eye movements were decreased. Frequencies of directional distributions are indicated in Table II. Data which include adjacent area of the strictly vertical and horizontal are shown by black bars in Figure 3. Here, the differences of the distribution between vertical and horizontal directions became extreme under the drinking-driving condition.

TABLE I *Reaction Time to the Ejected Dummy for Two Non-Drinking and Two Drinking Trials, in Seconds*

Driver type	normal		drinking	
	1st	2nd	3rd	4th
non skilled	1.41	0.96	0.21	0.16
skilled	0.73	0.08	–0.21[a]	0.31

[a] Fixated prior to appearance of the dummy

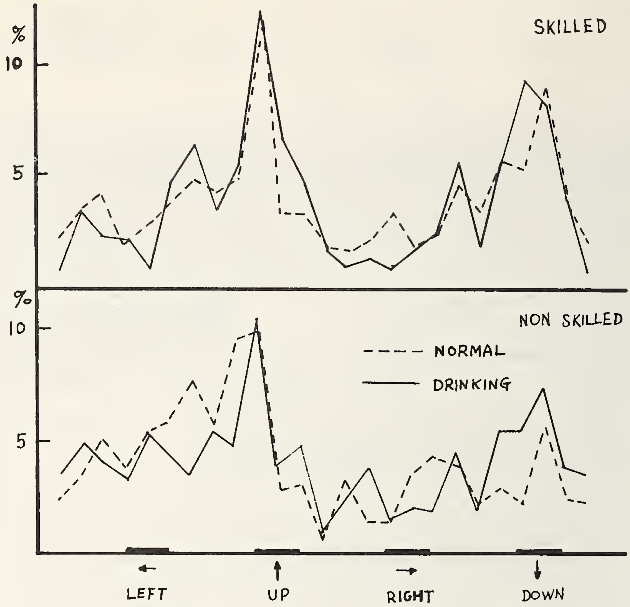


Figure 3 *Directional characteristics of saccadic eye movements (straight course, 1st trial), during non-drinking and drinking driving tests.*

We also studied the effects of alcohol on the distribution of eye fixation points. The data processing was done with the aid of a graph-pen which traced eye spots projected on 7 x 14 meshes and by mini-computer. As shown in Figures 4 and 5, the eye fixation patterns were strikingly modified under the drinking-driving condition. Figure 4 shows the distribution of eye fixation points for all data including straight and curved course driving. The black area in the Figure indicates a highly concentrated area of eye fixation (more than 10 per cent of the whole distribution).

In the drinking-driving condition fixation distribution for the non-skilled driver was scattered over a wider area than in the case of the skilled driver; both the whole area and the very dense area tended to shift downward (vertically). The same tendency is shown in Figure 5 in a much more exaggerated manner; here the data on curved road driving is excluded. Another characteristic worth noting is the shrinking of the fixation area under the drinking-driving condition.

TABLE II *Frequencies of Saccadic Movements in Strictly Horizontal and Vertical Directions, as Per Cent of Total Saccadic Movements*

Driver type		Normal		Drinking	
		horizontal	vertical	horizontal	vertical
non skilled	All data	25.5	27.7	15.8	35.8
	Straight course (1st)	25.0	26.3	18.5	36.5
	Straight course (2nd)	16.9	35.5	9.5	39.5
skilled	All data	19.4	34.6	13.3	37.8
	Straight course (1st)	17.0	38.3	13.8	46.0
	Straight course (2nd)	16.8	33.2	11.7	42.6

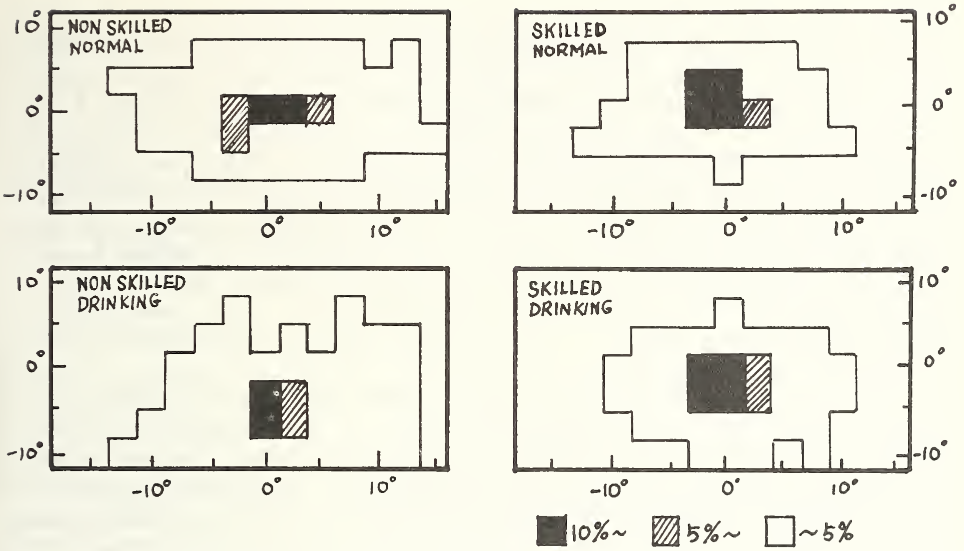


Figure 4 *Distribution of fixation points (all data).*

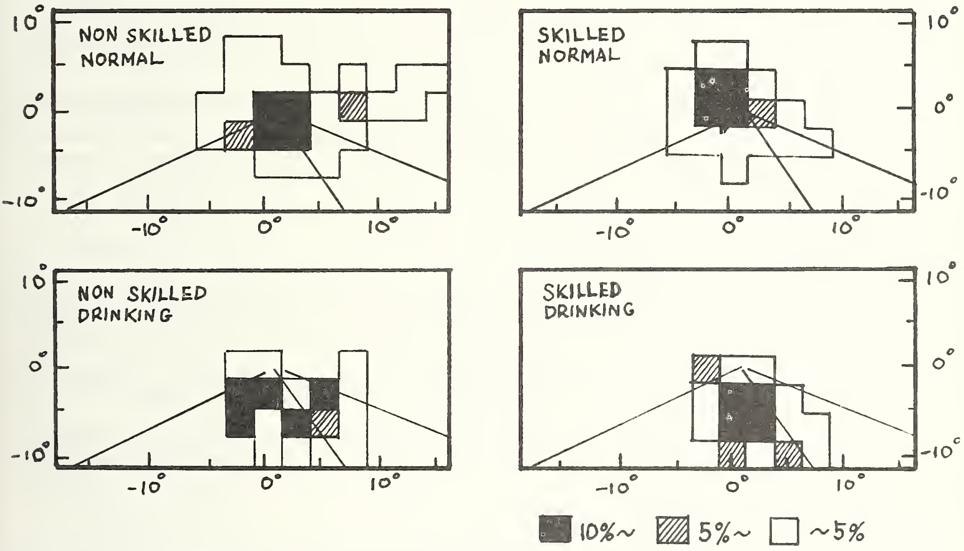


Figure 5 *Distribution of fixation points (straight course only).*

DISCUSSION

Delayed recognition of the dummy by the non-skilled driver who had no knowledge of the dummy ejection system was as expected. Accordingly, it is reasonable to assume that a delay of 1.41 seconds in recognition time for a real life driving situation, in which there is a sudden appearance of an object on the traffic scene, would occasionally take place. Although reduction of recognition time under the drinking-driving condition cannot be explained as the result of a single cause, learning through the 1st to 4th trials could result in drivers expecting the dummy to appear at the later trials. Both the expected behavior and the modified rapid eye movements might be affected by alcohol. Such a prolonged fixation duration in real driving could be dangerous.

Generally, the length of average fixation on a certain object while driving unimpaired by alcohol is between 0.3 and 0.6 seconds (at one time), and rarely exceeds one second (at one time) (1, 5, 6). Such prolonged fixation in this experiment may be caused either by alcohol or by the test course situation. At any rate, such fixation patterns must reduce the amount of information to be processed to some degree (2). Results in Figures 4 and 5 show that small doses of alcohol affect the fixation distribution of a driver's visual field and cause it to shrink, particularly for straight course driving (Figure 5), and this also suggests a close relation between alcohol and tunnel vision (3).

The tendency for the very dense area of fixation (black area in the Figures) to shift toward the bottom of the visual field may prove that a drinking-driver collects information at a shorter distance. If this is true for real life driving, the accumulation of uncertainty would be great and the driver would have to reduce his driving speed to accommodate a complex traffic situation (2). However, under the drinking-driving condition, radical speed reduction is unlikely since the drinking-driver is expected to take risks.

Since alcohol-influenced drivers normally neglect to reduce their driving speed it has been concluded by many researchers, and from the present results, that intoxicated drivers might have difficulty in maintaining an optimal information processing rate.

Such downward modification of fixation patterns while drinking-driving as shown in Figures 4 and 5 might be caused by muscular dullness produced by alcohol; this assumption will be checked by the electrooculogram (EOG) technique.

REFERENCES

1. Gordon, D. A., Experimental isolation of the driver's input, *Human Factors* 8, 129 (1966).
2. Markowitz, J. and Dietrich, C. W., An investigation of the design and performance of traffic control devices. CPR-11-5955, no. 1726, 2-18 (1968).
3. Moskowitz, H. and Depry, D., Differential effect of alcohol on auditory vigilance and divided-attention tasks. *Quarterly Journal of Studies on Alcohol* 29, 54 (1968).
4. Moskowitz, H., Laboratory studies of the effects of alcohol on some variables related to driving. Alcohol and Road Safety Conference of the CCM Road Safety Project and OECD (1972).
5. Mourant, R. R., Driver's eye movements and visual work load, *Highway Research Record* 292 1 (1969).
6. Murata, T. and Nakamura, Y., Driver's eye fixation points, *Traffic Engineering (Japan)* 5, 7 (1970).

Computer-Electronystagmography: A Useful Tool in Evaluating Influence of Psychopharmacological Drugs on Traffic Safety

Jürgen C. Aschoff,[1] Wolfgang Becker and Dieter Weinert

Reliable tests for measures of alertness, the state of arousal or vigilance, all of which can be used synonymously, have long been of interest in experimental psychology. In modern aviation and space medicine as well as for problems associated with the increasing traffic density, changes in vigilance are of major importance because they represent an uncontrolled safety factor. Special psychological tests have been used as an index of moment-to-moment and day-to-day changes in vigilance such as skin resistance, heart rate, fluctuations in respiration, EEG-changes, tapping rates or other simple motor performances, reaction times, tremor and hand-steadiness measures. The EEG is viewed as the most reliable test procedure but computer analysis of electroencephalograms are still in a developmental state and need extensive and expensive equipment.

We have found that the analysis of saccadic eye movements is useful in assessing the state of vigilance (1,2). Saccadic eye movements – the flick-like movements of the eyes which occur as gaze is shifted from one point of interest in the visual surroundings to another – have generally been accepted as invariant for a given subject. The velocity of these saccades is too high for continuous feedback regulation while the eye is actually in motion. The eyes therefore jump with a ballistic type of movement, and most often do not reach exactly the preselected target point. Following this first saccade, a corrective saccade is needed after the error is perceived. From this it is obvious that velocity and duration as well as the error of saccadic eye movements cannot be changed at will. Velocity and duration, and to some extent the error of movement, are entirely dependent upon the magnitude of the eye movement.

Velocity, duration and accuracy of saccadic eye movements can therefore be viewed as relevant criteria for psychomotor performance in man. While these parameters cannot be changed voluntarily, it has been found by various workers that fatique, extended periods of wakefulness (7), alcohol (4), or tranquilizers (5,6) show striking and reproducible effects on the oculomotor system: the velocity of eye movements decreases (8), duration and saccadic reaction time increase, and eye movements are executed less accurately than under normal circumstances.

The influence of psychopharmacological drugs on vigilance and psychomotor performance is of considerable interest, seeing that these drugs are used on a vast scale throughout the population without proper controls. We have chosen two drugs, (1) the

---

[1] University of Ulm, Department of Neurology, 9 Steinhövelstraße, 79 Ulm, West Germany.

well known tranquilizer diazepam and (2) a new psycho-active drug with a chemical structure and therapeutic properties different from any other psychotropic drug currently in use. The generic name is sulpiride, a chemical derivative of metoclopramide, with therapeutic effects somewhere between the neuroleptics and thymoleptics, sulpiride can also be used as a powerful suppressant of vestibular vertigo. It has been claimed that sulpiride, in spite of its neuroleptic and thymoleptic action, does not interact with the patient's alertness (3). Short and long term experiments were performed with these two drugs, whereby velocity, duration, accuracy and reaction times of saccadic eye movements were recorded, analysing and computed with out PDP-12 laboratory computer.

METHODS

Ten persons participated in short term tests, and five persons in a long term test. In the short term test saccadic eye movements were always recorded in the late afternoon. Tests were carried out in all ten subjects following a medication of 4 x 100 mg sulpiride started the previous evening. One week later the test was repeated with five persons receiving 5 mg diazepam and with the other five persons receiving 10 mg diazepam. In a previous experiment six persons had received 5 mg diazepam intravenously. In the long term experiment five subjects were investigated each participating in four experiments. Two experiments were conducted with no drug given. One experiment was undertaken after 3 x 5 mg diazepam a day for one week, the last experiment after a daily administration of 3 x 100 mg sulpiride during one week. The sequence of experimental conditions was randomly varied between the five subjects.

Procedure Used to Record Eye Movements

Eye movements are recorded by means of the bitemporal electrooculogram (EOG). After amplification (dc-amplifier) the signal is fed into a PDP-12 laboratory computer and monitored on an ink-writer. The PDP-12 computer simultaneously controls the experimental sequence and measures the subject's eye movements retaining all relevant data.

Subjects are seated facing a TV screen with the head fixed. A single light-spot is displayed on the screen as fixation target. The target can appear only in the horizontal plane to the left or to the right of the subject's primary direction at 0°, 10°, 20° or 30°. On pressing a button the operator causes a jump of the target from one to the next position. The sequence of succeeding positions is determined by a random list stored in the computer memory. By pressing the button the operator calls the next entry from that list which is then converted into an analog voltage which controls the target position. The subjects were instructed to fixate upon the target and to track target jumps as fast and as accurately as possible. Eye movements in this situation are exclusively saccadic in nature as opposed to smooth pursuit movements. In each experiment 512 eye movements are recorded and analysed.

Data Acquisition

From each saccadic reaction the following parameters were measured by the PDP-12 computer: 1) latency between target jump and onset of the saccade (reaction time) 2) amplitude of the saccade and 3) maximum velocity of the eye movement.

The automatic data acquisition of these parameters involved the following steps. The output of the dc-amplifier (amplified EOG) was adjusted approximately to a value of 0.5 volts per 100°, and was subsequently differentiated by an analog computer. If the differentiated signal (eye movement velocity) exceeded a critical threshold the analog computer would generate an impulse indicating the occurrence of a saccadic movement. The three outputs of the analog device (adjusted EOG signal, velocity signal, and saccade pulse) were sampled by the PDP-12 computer at a rate of 400 Hz. At the occurrence of a saccade pulse the PDP-12 would check the EOG pattern against a set of given time and amplitude criteria which are characteristic for saccadic eye movements. If these saccadic criteria were met, the computer would store the amplitude of the target jump and the 3 parameters described above. Exact calibration was performed by recording eight target jumps of 40° amplitude.

Statistical Treatment of Computer Data

Statistical treatment was carried out for the following parameters retrieved from the PDP-12 computer: 1) amplitudes (average and standard deviation (SD)) of the eye movements as a function of the target amplitude, 2) saccadic reaction times (average and SD) pooled for all saccades, and 3) maximum velocity (average and SD) of the saccadic eye movements as a function of their amplitude. Amplitudes were sorted into ten degree bins. Mean values obtained in different experimental conditions were then tested for the null-hypothesis by means of the Wilcoxon-test for ranged matched pairs. The level of statistical significance was fixed at 10%. Ratios of variances were compared by means of the F-distribution, the level of significance being 5%. The statistical procedures did not take full advantage of the capabilities of our PDP-12 computer. However, in these pilot experiments we refrained from carrying out a complete program of multiple factor variance analysis; instead we stressed the qualitative aspects. Further experiments will have to be based on a rigorous variance analysis.

RESULTS

Saccadic Velocity and Duration

An example of a computer plot of maximum angular velocity is shown in Figure 1, and of saccadic duration in Figure 2. Each dot represents a single eye movement. No significant difference was found between the short term and long term experiments. Diazepam always produced a significant reduction of saccadic velocity as well as an increased saccadic duration and standard deviation. On the other hand, only a slight change could be produced with sulpiride.

Mean values for maximum velocities are shown in Figures 3 and 4. In Figure 3 an example is given for a single subject (one of the authors), in which diazepam produced marked reduction in saccadic velocity while sulpiride matched even the faster velocities of the two tests under normal conditions. Slowing of angular velocity of eye movements under the influence of psychopharmacological drugs is a dose-dependent effect, as seen in Figure 4. Mean reduction of angular velocity amounts to 2.5% under sulpiride medication, and, depending upon the dose, to between 11 and 21% following a diazepam medication. All eye movements can be plotted and analysed, therefore, either for a single person or for a group, for short term effects or for long term effects. No difference has been found between measurements of saccadic velocity (Figure 1) or of saccadic duration (Figure 2). Either one of the two parameters can be used for retrieving the information described above.

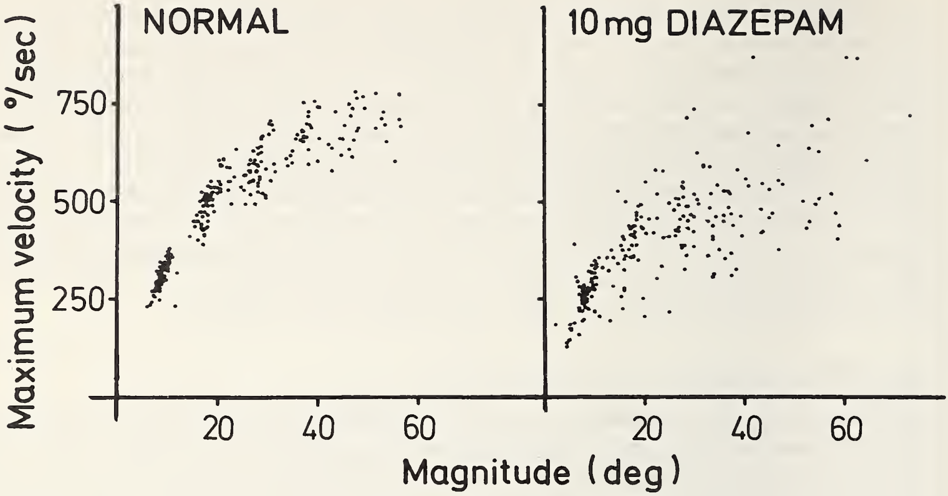


Figure 1 *Computer plot of saccadic eye movements: maximum angular velocity against magnitude of eye movements. Each dot represents a single saccade. On the right: slowing and deterioration of eye movements following diazepam medication.*

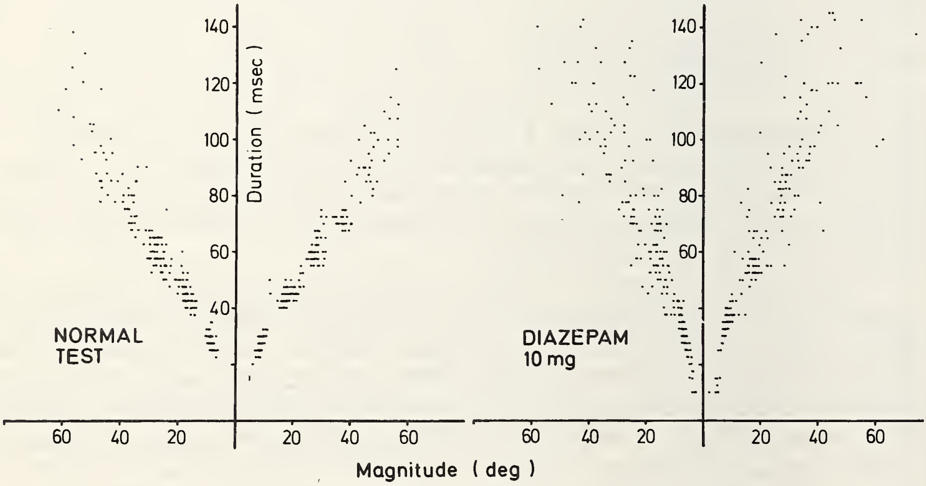


Figure 2 *Computer plots of saccadic eye movements. Duration of movement is plotted against amplitude. Movements to the right and to the left are plotted separately. Increased duration following 10 mg of diazepam.*

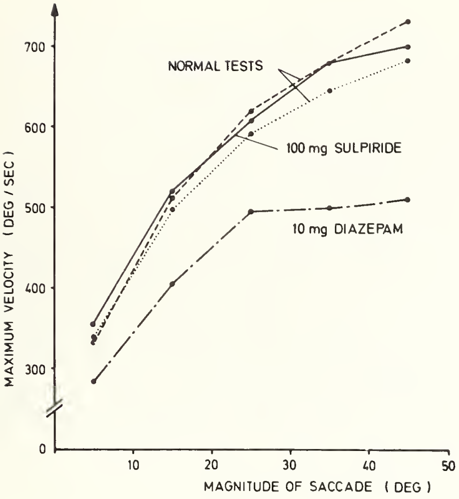


Figure 3 *Maximum angular velocity of saccadic eye movements in subject A. Each line represents 500 eye movements. No change occurs after sulpiride medication while diazepam reduces significantly angular velocity.*

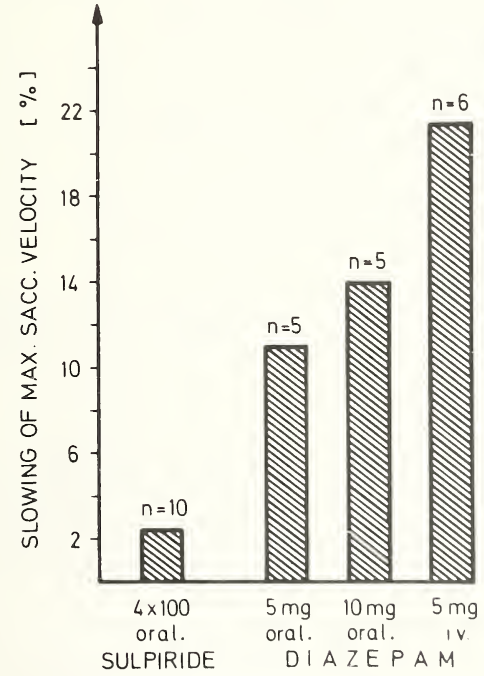


Figure 4 *Maximum angular velocity of saccadic eye movements following therapeutic doses of sulpiride and of diazepam.*

Accuracy of Eye Movements

Normally a voluntary saccadic eye movement is executed some degrees short of the preselected target point, a phenomenon called hypometria. Around 100 msec after this first saccade a corrective saccade must therefore follow. The amount of hypometria can be taken as an objective measurement of psychomotor performance. In Figure 5 and 6 "normal I" and "normal II" correspond to the two tests carried out under normal conditions while "Sulpiride" and "Diazepam" represent mean values of the five subjects who participated in the long term experiment. In Figure 5 the error has been plotted against the target angle. As can be seen, psychomotor performance under the influence of sulpiride either matches the performance during the better of the two normal tests (Figure 5), or is even enhanced with regard to the variance in this error (Figure 6). Diazepam, in contrast, causes a marked hypometria; the standard deviation is three times higher than under normal conditions. The two plots give useful information about differences between normal tests as well as about changes in oculomotor performance under the influence of either sulpiride or diazepam.

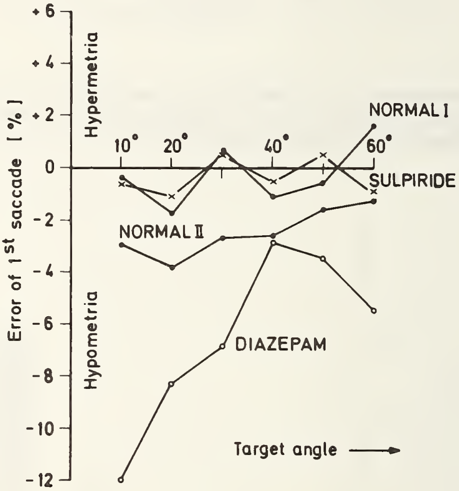


Figure 5 *Analysis of accuracy of human eye movements indicating psychomotor performance. Following medication of sulpiride the oculomotor behavior matches the performance of the better of two normal tests. Diazepam causes marked hypometria.*

Saccadic Reaction Time

All subjects were asked to follow and fixate the computer-switched target point as rapidly as possible. The time difference between the computer-triggered jump of the light-spot and the start of saccadic eye movement is termed the saccadic reaction time. This reaction time is independent of saccadic amplitude, with only an insignificant increase towards larger angles.

Mean values in the long term experiment are shown in Figure 7. There is clear indication that diazepam impairs oculomotor function while sulpiride does not. An example of excessive changes in reaction times in a single person (subject F) is given in Figure 8: a weekly medication of diazepam increases reaction times significantly, the longest reaction times being twice the normal values.

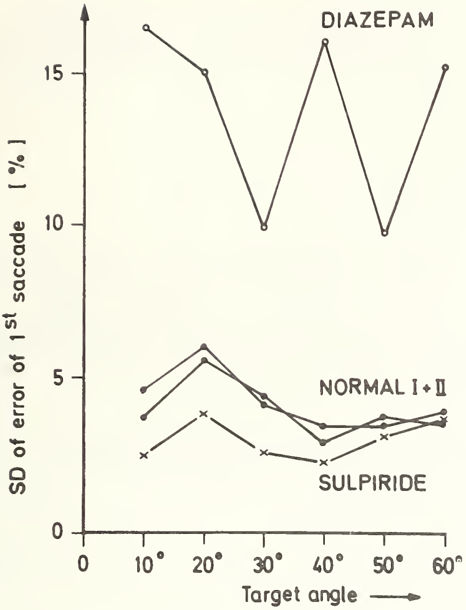


Figure 6 *Standard deviation in the error of the first large saccade as an indicator for accuracy in oculomotor performance.*

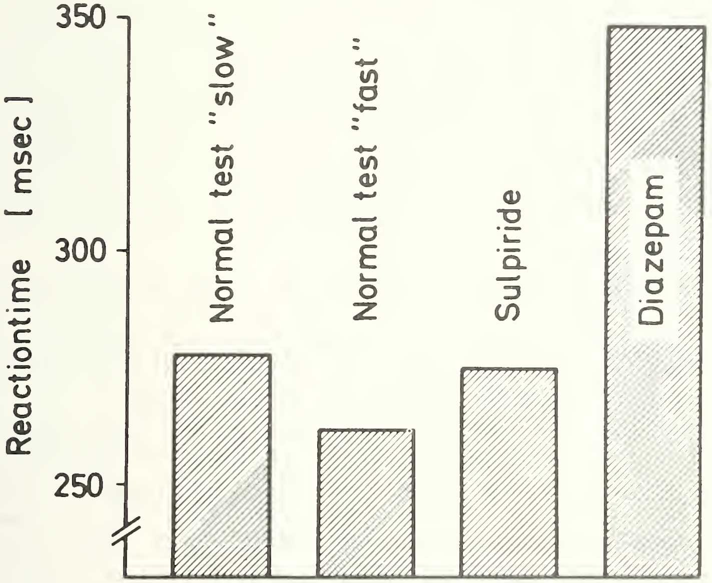


Figure 7 *Reaction times of saccadic eye movements. Pooled data from 5 subjects. From the two tests under normal conditions the faster reaction times from each person have been pooled and marked as "normal fast", the slower test is called "normal slow". Each bar represents 2500 reaction times.*

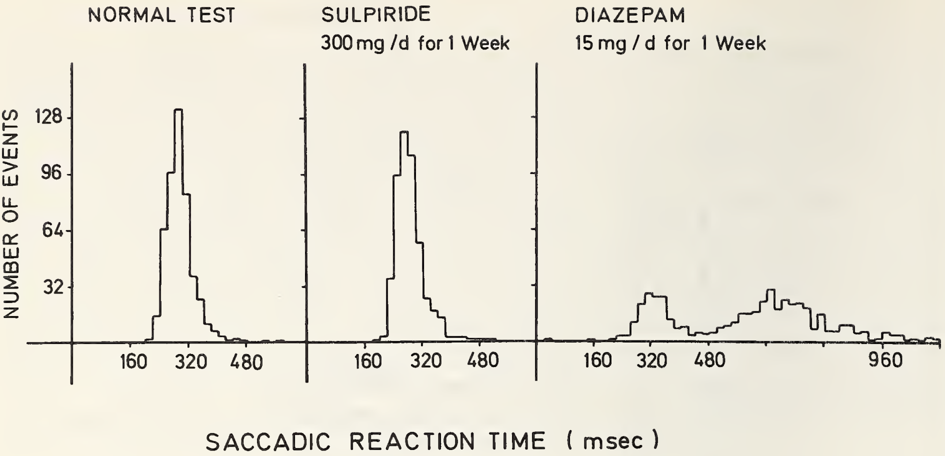


Figure 8 *Saccadic reaction times of subject F.*

DISCUSSION

For all data, statistical analysis was performed according to the procedure described above. It is not the purpose of this paper to show statistical differences between the effects for different psychopharmacological drugs, nor between these substances and the normal state. It is, however, of interest that the statistical analysis has proven that the maximum velocity and the accuracy of human saccadic eye movements showed consistent and significant differences between the two substances tested, while reaction times were less useful. In summary, sulpiride, both in the short as well as in the long term experiments, produced slight but not statistically significant reduction of maximal angular velocity of saccadic eye movements. Diazepam, as compared to sulpiride and non-drug conditions, significantly reduced eye movement velocity in the short as well as in the long term experiments. Marked differences were detected between different subjects.

The most useful analysis turned out to be the measurement of accuracy of eye movements. In all subjects, accuracy decreased under the influence of diazepam, whereas sulpiride led to an equal or better performance than that seen under normal conditions. The results, therefore, support the findings of (3) who reported increased attention and better psychomotor performance following sulpiride.

We strongly suggest that angular velocity, accuracy and saccadic reation times of eye movements, measured and analysed as described, should be used as test procedures in evaluating psychopharmacological or other drugs with respect to traffic safety. These tests are reproducible, objective, and the results cannot be voluntarily influenced. Data sampling is easy, and the duration of one test (500 eye movements) amounts to less than two hours. If normal tests have been performed previously, at the end of each experiment, changes in psychomotor performance and vigilance produced by any given drug, can be taken from the computer in absolute or percentage values.

Maximum angular velocity indicates mainly changes in vigilance, while the error of the first large saccade with respect to the preselected target point is especially representative for changes in psychomotor performance. These two parameters exhibited consistent changes in all subjects tested under various conditions and may therefore be used in evaluating group reactions. Measurements of saccadic reaction times are less useful for group reactions but may be used as a sensitive indicator for individual changes in vigilance.

REFERENCES

1. Aschoff, J. C., Veränderungen rascher Blickbewegungen (Sakkaden) beim Menschen unter Diazepam, *Archiv Für Psychiatrie und Nervenkrankheiten* **211**, 325-335 (1968).
2. Aschoff, J. C., Characteristics of Voluntary Saccadic Eye Movements and Their Importance for Pilot Performance. AGARD Conference Proceedings. 61: *Recent advances in Aerospace Medicine,* 1970.
3. Crocq, L., Proceedings of the International Congress of Psychiatry. Mexico City, 1971.
4. Franck-Hanusch, M. C., Die Wirkung des Alkohols auf die raschen Blickbewegungen beim Menschen. Dissertationsschrift, Universität Freiburg/Br. (W. Germany), 1969.
5. Frecker, R. C., Llewellyn-Thomas E., Saccadic Eye Movements Velocity as an Indicator of Dose Level of Diazepam, Pentobarbital and D-amphetamine in Humans. *Journal of Pharmacology 5, Suppl. 2*, **32** (1974).
6. Gentles, W., Llewellyn-Thomas, E., Effect of Benzodiazepines upon Saccadic Eye Movements in Man. *Clinical Pharmacology and Therapeutics* **12**, 563 (1971).
7. Kris, C., Electro-oculography. In Glasser, O. (Ed.), *Medical Physics* Vol. III, Chicago, Year Book Publishers (1960).
8. McCabe, B. F., Sekitani T. and Ryn J. H., Drug Effects on Postlabyrinthectomy Nystagmus. *Archives of Otolaryngology* 98, 310-313 (1973).

Effects of Low and Moderate Levels of Alcohol on Steering Performance

R. G. Mortimer[1,2] and S. P. Sturgis

The role of alcohol in degrading highway safety has been clearly documented in many previous studies (6, 11, 29). About 50 per cent of the drivers and pedestrians involved in fatal collisions have significant levels of alcohol in their blood. These trends, found in the United States, also occur in other countries (7, 10, 22, 23). While there is no longer any doubt that the presence of alcohol in the blood of drivers and pedestrians renders them highly susceptible to highway accidents, there is less known about the nature of the impairment of alcohol on human behavior. While studies have been made to evaluate the effects of alcohol on specific perceptual and simple motor tasks, the findings are generally not clear-cut, and the relevance of such tasks as components of the skills required for driving is not understood. However, a potential application for this type of research is in the development of tasks that can be used as ignition interlocks (27) which would prevent intoxicated drivers from starting their vehicles. Some potential tasks that have been examined include: tracking, complex reaction time, and divided-attention tasks, which tend to be impaired at a blood alcohol concentration of 0.10% (g/100 ml) or less.

The evaluation of the effects of alcohol on skills required in driving has also been done using stimulations at various levels of sophistication. Drew *et al* (5) found that tracking performance deteriorated at low BACs, of the order of 0.03%. Another tracking study, made to stimulate the illumination and glare of headlamps in night driving, found decrements in tracking performance at BACs of less than 0.02% (12).

By contrast, some studies using driving simulators (3) have not found decrements in various performance measures. In a subsequent study by Moskowitz (17) using the same simulator as used by Case *et al* (3), there were differences in tracking attributable to alcohol when a side-task was added. The effect of alcohol in tasks requiring time-sharing has also been documented in other experiments (8, 9, 16, 18, 19).

Other studies have used automobile driving tasks, usually at quite low speeds. Studies such as those carried out by Bjerver and Goldberg (2) and Perrine and Huntley (20) have found some differences in driver performance attributable to BACs as low as 0.05%.

[1] Highway Safety Research Institute, University of Michigan, Huron Parkway at Baxter Rd., Ann Arbor, Michigan 48105, U.S.A.

[2] This study was supported by the National Institute on Alcohol Abuse and Alcoholism, Grant No. 5 R01 AA00295-02.

A study by Cohen *et al* (4) indicated that alcohol degrades the ability to make judgments (in this instance, judgments of the adequacy of the size of gaps to drive through), which was interpreted as an increase in risk acceptance. An experiment by Snapper and Edwards (24) found, however, that alcohol impairs a vehicle control task, but not the judgment as to the likelihood of success in a severe handling maneuver.

Thus, studies have been carried out that indicate that alcohol impairs a number of abilities as measured in laboratory, simulation and actual driving tasks, and in the performance of drivers on the roads as measured by the ultimate criterion of collision frequency and severity (28).

There is still a lack of information, however, of which specific aspects of driver behavior are impaired by alcohol. The studies of Moskowitz (e.g. 16) and others have shown that alcohol affects the manner in which the driver processes information. Studies conducted to evaluate the manner in which the driver acquires visual information, such as by Belt (1) and Mortimer and Jorgeson (15) have shown some narrowing in the lateral field-of-view scanned by drivers, an increase in the mean fixation time of glances, and a reduction in the distance of the eye fixations ahead of the vehicle, attributable to alcohol. Such findings also show that the manner in which the driver acquires information for controlling the vehicle and avoiding obstacles, is different when he is under the influence of alcohol than when he is sober.

There are a number of basic cues available to drivers which can be used for steering a vehicle along the road. Previous studies of tracking performance under alcohol have not attempted to isolate these components of the driver's cue structure. Weir and McRuer (32) have suggested that the primary guidance cues used by drivers consist of the lateral position and path angle or heading angle of the vehicle (Figure 1). The derivatives of these measures may also provide important cues to drivers.

By isolating the components of the cue structure drivers use for controlling the path of a vehicle, it may be possible to define the effects of alcohol on the steering task more clearly by noting its influence upon them. This is the strategy that was used in this experiment.

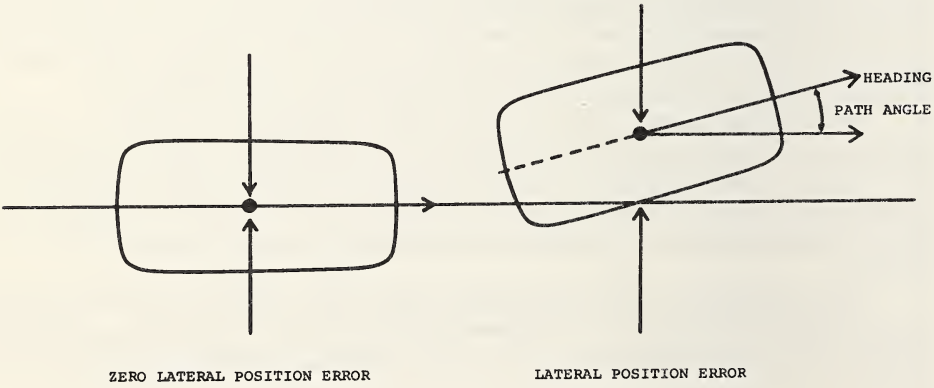


Figure 1 *Vehicle trajectory diagram.*

METHOD

Subjects

A total of 18 subjects, eight females and ten males, were paid to participate in the experiment. They were administered the "Mortimer-Filkins" test (14) which consists of a self-administered questionnaire and a structured interview to assess problem-drinking. The test also obtains background and driving experience information. The subjects were randomly assigned, by sex, to either placebo or alcohol treatment groups.

Ages, years of driving experience and "Mortimer-Filkins" test scores of the subjects did not differ significantly according to analyses of variance. Means and standard deviations are shown in Table I. Three of the subjects in each group were diagnosed as problem drinkers or presumptive problem drinkers, representing a rate higher than would be expected in the population of drivers.

TABLE I *Characteristics of the Test Subjects*

	Age		Driving Experience Years		Mortimer-Filkins Test Score	
Group	Mean	SD	Mean	SD	Mean	SD
Placebo	25.6	3.5	9.5	3.7	45.5	25.8
Alcohol	29.4	8.4	11.7	8.8	50.6	28.6

The Closed-Loop, TV Display Driving Simulator

The tests were conducted using a driving simulator which provides a visual display of the lateral and longitudinal motions of a simulated vehicle, which are controlled by steering inputs from the subject-driver. A straight two-lane roadway, delineated on a continuous belt, 48 in. (122 cm) wide and 40 ft. (12.2 m) in length, is supported by a wooden table. The belt is driven by a variable speed motor. Although velocity of the simulated vehicle can be controlled with brake and accelerator pedals mounted at the driver's position, all simulator tests in this experiment were made at a fixed, simulated speed of 40 mph (64.4 kph). A video camera mounted on a gantry at one end of the belt (Figure 2) has two degrees of freedom, about the yaw center of motion of the camera and perpendicular to movement of the belt, and provides an image of the roadway to the driver on a TV monitor, which measures 25 in. (63.5 cm) across the diagonal (Figure 3).

Driver steering inputs are translated through an electronic vehicle-response analog to the camera-gantry system, resulting in realistic yaw and lateral movement of the simulated vehicle.

Analog performance data (steering wheel angle, lateral position error, path angle) are recorded on an FM tape recorder for subsequent digitization and computer analysis.

The use of electronic circuitry to control yaw and, thus, lateral position of the video camera makes it possible to electronically introduce path angle errors which

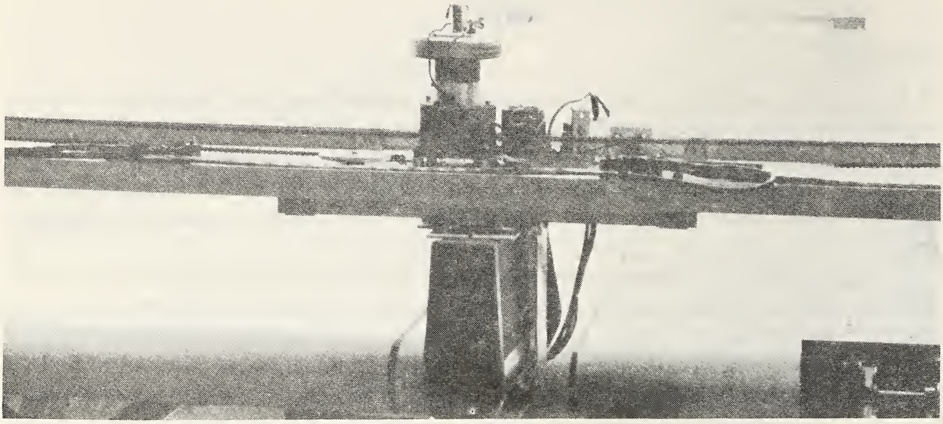


Figure 2 *Camera servo and roadway belt.*

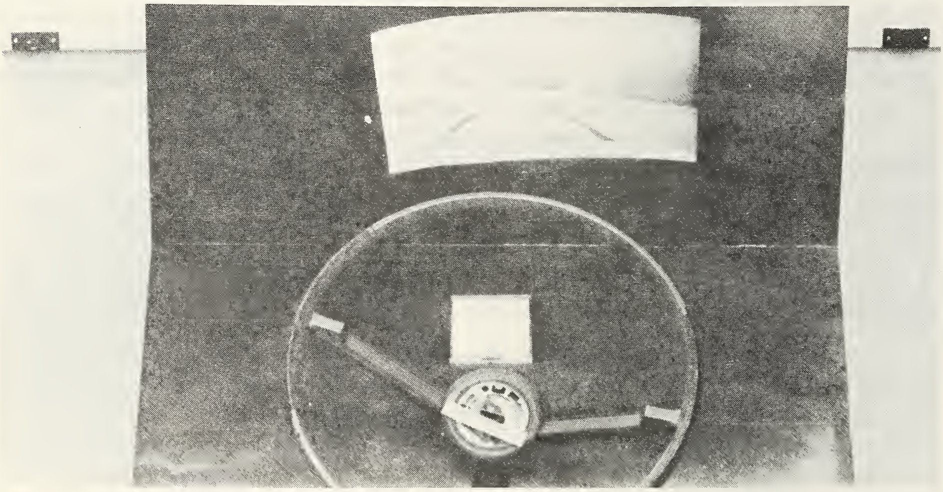


Figure 3 *Driver's station and T.V. display.*

produce lateral position errors to be controlled by the driver. Figure 1 defines the lateral position error and path angle that can be assumed by the vehicle. It should be noted that a motor vehicle, normally equipped with tires, will produce path angles that are made up of two components consisting of the heading angle and the side-slip angle. Side-slip angles are generally of small magnitude, but depend upon the mechanical characteristics of the tires and the lateral forces to which they are exposed. In the simulator, side-slip angles are ignored since the vehicle response that is displayed to the driver is the sum of the heading angle and side-slip angle, to produce the path angle. No attempt was made to measure individually both heading angle and side-slip angles.

In this experiment, disturbances in path angle were introduced as continuous, pseudo-randomly varying electronic steer angle disturbances which simulated cross winds of varying magnitude, frequency, and direction. Each driving session lasted about 30 minutes, and included four trials of 40 seconds when the continuous disturbance was applied, interspersed with other conditions.

Administration of Alcohol Doses

The procedure followed on both days of the experiment was identical for placebo and alcohol subjects. Only the contents of the drinks administered on the second day differed. On both days, the subjects were tested during the afternoon. On the second day, after having received instructions to fast for at least an hour and a half prior to reporting to the laboratory, the subjects were given 15 minutes to consume a drink containing either a low-calorie carbonated soft drink and 200° alcohol or the soft drink with a small amount of alcohol floated on top to simulate the alcohol dose flavor.

Forty-five minutes after finishing the drink, each subject was given a breath test, followed by one session of driving in the simulator. Another breath test was then given, and a second drink administered. Twenty minutes after consuming the second drink, a second simulated driving test was made. Breath tests were made at the middle and end of this testing period. Approximately two hours after the second testing period (or when the BAC of subjects in the alcohol treatment group declined to 0.07%) the third simulator test of the day was made. During the two-hour rest period, subjects were allowed to eat a late lunch and relax in a secluded room. The first alcohol dose was formulated to provide BACs of $\simeq$0.07%, the legal cut-off for impaired driving in the State of Michigan. The second alcohol dose was formulated to produce a mean BAC of $\simeq$0.10%.

Body build has been found to be an important parameter in determining alcohol doses, as subjects of the same total body weight but with different amounts of body fat, will typically reach different peak BACs. Sturgis (25) administered alcohol to 16 subjects in a study concerning the effects of alcohol on psychomotor skills and found great variation in peak BACs when a strict body weight formula was used. Peak BAC was ostensibly positively correlated with amount of body fat. With a target peak BAC of 0.10%, actual values of 0.075 to 0.13% were attained. Wallgren and Barry (30) have noted that alcohol is only slightly soluble in tissue lipids. At body temperature, lipids absorb only about 4 per cent of the quantity of alcohol dissolved in a corresponding volume of tissue water. Total body weight is thus not always an accurate estimator of soluble body mass. Widmark (according to Wallgren and Barry (30)) described the factor r to represent "reduced body mass" which signifies "the fraction of the body volume in which alcohol would be present if it were distributed at a uniform concentration equal to that observed in the blood." Widmark empirically determined r for 20 male subjects and found a mean of 0.68 and a standard deviation of 0.085. Clearly, r must be taken into account for accurate calculation of doses.

Snapper and Edwards (24) employed a dosage formula designed to provide BACs of 0.10% which required visual estimates of subjects' body fat, and had considerable success in reducing the variance in resultant peak BACs. An adaptation of their formula is shown in Figure 4. The formula is based on empirical findings that a dose of 0.48 ml of absolute alcohol per pound of body weight (or 0.83 g/kg) results in an average peak BAC of 0.10% in fasting subjects. In addition, it enables correction for different amounts of body fat by estimates in standard deviation units of the divergence subjects' body fat from 'average'. One standard deviation is equal to $\simeq$ 8.5% of the average dose. Thus, a subject weighing 154 pounds (70 kg) could receive a dose of from 61 to 86 ml (0.69 to 0.97 g/kg; ± 2 SDs.) of absolute alcohol depending upon his estimated body fat.

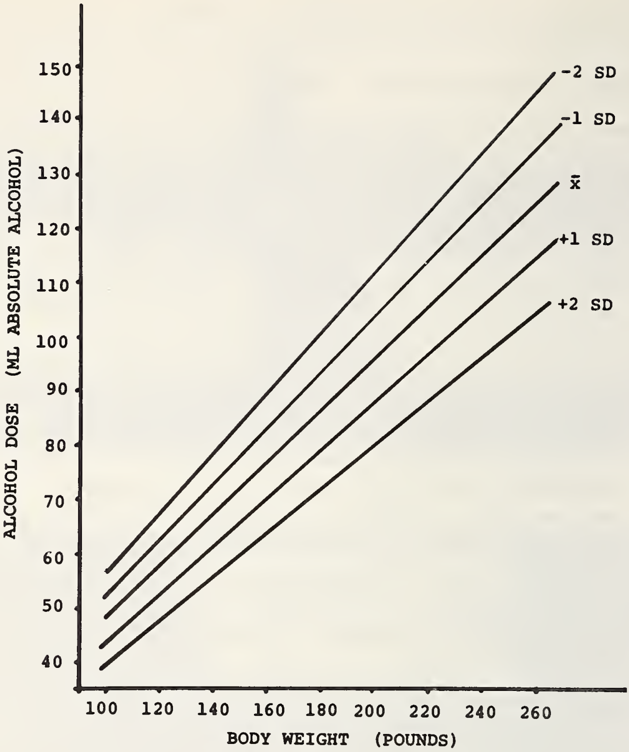


Figure 4 *Alcohol doses required for peak BAC of 0.10% (g/100 ml) by total body weight and experimenter's estimate of body fat in standard deviation units.*

In this study, a similar formula was used, but the average first alcohol dose was 0.34 ml of absolute alcohol per pound of body weight (0.58 g/kg), mixed 1:6 with a low-calorie carbonated soft drink. The second dose contained a mean of 0.24 ml alcohol per pound (0.42 g/kg) mixed in the same ratio.

Instructions and Incentive Structure

The subjects were instructed to drive the straight road, maintaining the vehicle in the center of the roadway lane as well as they could at all times.

As an incentive for accurate simulator performance, each subject was told that his performance would be compared with that of the other subject who was participating on the same days, and that the one who obtained the lowest cumulative lateral position error score in driving the simulator would receive a bonus payment of ten dollars.

Experimental Design

Since large learning effects were known to exist in steering performance in the driving simulator, the subjects were given two practice sessions prior to receiving treatment doses.

The study incorporated a between-groups design, in that subjects were tested under one treatment condition only. Statistical analyses of treatment effects, however, were made through both between-and within-groups tests of the interaction of test session (control/practice vs treatment) and treatment condition (placebo vs alcohol). On the first day, all subjects received two practice sessions in the driving simulator. On the second day, the alcohol group's three driving sessions were conducted at target BACs of 0.07% during uptake; 0.10% and 0.07% during alcohol elimination.

RESULTS

BAC Levels

The means and standard deviations of the BACs achieved by the placebo and alcohol groups in the three test sessions on the second day are shown in Table II. The values shown are the means of readings taken at the start and end of each of the testing periods.

TABLE II *Target BACs and Means and Standard Deviations of BAC Levels Achieved*

Session	Target BAC (g/100ml)	Achieved BAC (g/100ml) Mean	SD
3	0.07	0.076	0.013
4	0.10	0.098	0.005
5	0.07	0.067	0.004

Means of Steering Performance Variables

Mean lateral position error was found by analysis of variance to be significantly greater at 0.10% BAC than in the placebo condition (Figure 5). No significant differences were found between the placebo and alcohol groups for steering wheel displacement, path angle and yaw rate.

Time-Series Analyses of Driver Performance

Time series analyses of these data were also made. Examples of these are shown in Figures 6-9, for the power spectra of steering wheel displacement, lateral position error, path angle, and yaw rate used by a placebo and an alcohol subject in two separate sessions. Session 2 indicates performance on the last practice series of trials on day 1, and session 4 shows performance on day 2 under 0.10% mean BAC for the subject in the alcohol group and the equivalent trial for the placebo subject. Figure 6 shows the power spectra of steering displacement in sessions 2 and 4 for subject D in the placebo group and subject F in the alcohol group. It will be noted that the steering wheel frequency response of the placebo group subject peaked at about the same value (*i.e.*, 0.3 Hz) in both sessions and that the bandwidths in both trials are about the same.

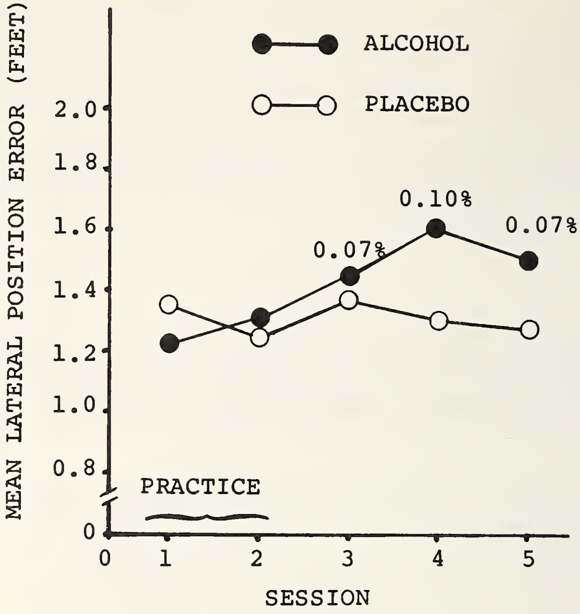


Figure 5 *Mean lateral position error.*

Also, the curves show that the total RMS (root mean square) power of steering wheel displacement, which is the square root of the area under the curve was less in session 4 than 2, showing a reduction in steering wheel activity attributable to practice between sessions 2 and 4.

The subject (F) in the alcohol group used a peak steering wheel frequency of about 0.28 Hz in practice session 2. In session 4, subject F carried out the same task at 0.10% BAC, which resulted in a reduction of his peak steering wheel frequency to about 0.20 Hz, as well as a reduction in the steering wheel response frequency bandwidth. There was also a change in the RMS of the steering wheel displacement, with an increase in the alcohol condition.

Comparing the behavior of the placebo and alcohol subjects shows that alcohol reduced the steering wheel response peak frequency and the frequency bandwidth, while increasing the total extent of steering wheel movement relative to performance without alcohol.

Figure 7 shows similar comparisons for the lateral position error power spectra, and Figures 8 and 9 for path angle and its derivative, yaw rate, respectively. In each case, the dominant peak frequency and bandwidth of the subject in the placebo group are not changed, but there is a reduction in the RMS values, indicating a reduction in steering wheel displacement, lateral position error, path angle and yaw rate deviations, showing that performance in vehicle control improved as a function of practice.

The alcohol group subject performed similarly to the placebo subject in the practice session 2, while there was a reduction in his peak frequency and bandwidth of all signals under alcohol. This was accompanied by an increase in RMS in all signals, showing that although the subject increased the amplitude of steering corrections, there was a decrement in vehicle control performance.

These examples are for two specific subjects, one belonging to the control group and the other to the alcohol group. Of course, individual differences in the responses of subjects under alcohol are to be expected.

Analyses of this type were made for 16 subjects because of some missing data for two subjects. The means of the frequency bandwidths of the signals for eight placebo and eight alcohol group subjects over the five test sessions are shown in Figure 10. Sessions 1 and 2 are practice sessions which were made on the first day. Sessions 3, 4 and 5 were given on the second day. Session 3 is the 0.07% BAC session during uptake, session 4 is at 0.10% BAC and session 5 is at 0.07% BAC, during alcohol elimination, for the alcohol group. For the placebo group, the same temporal sequence of ordering of the sessions was used, but the drinks contained only a trace of alcohol.

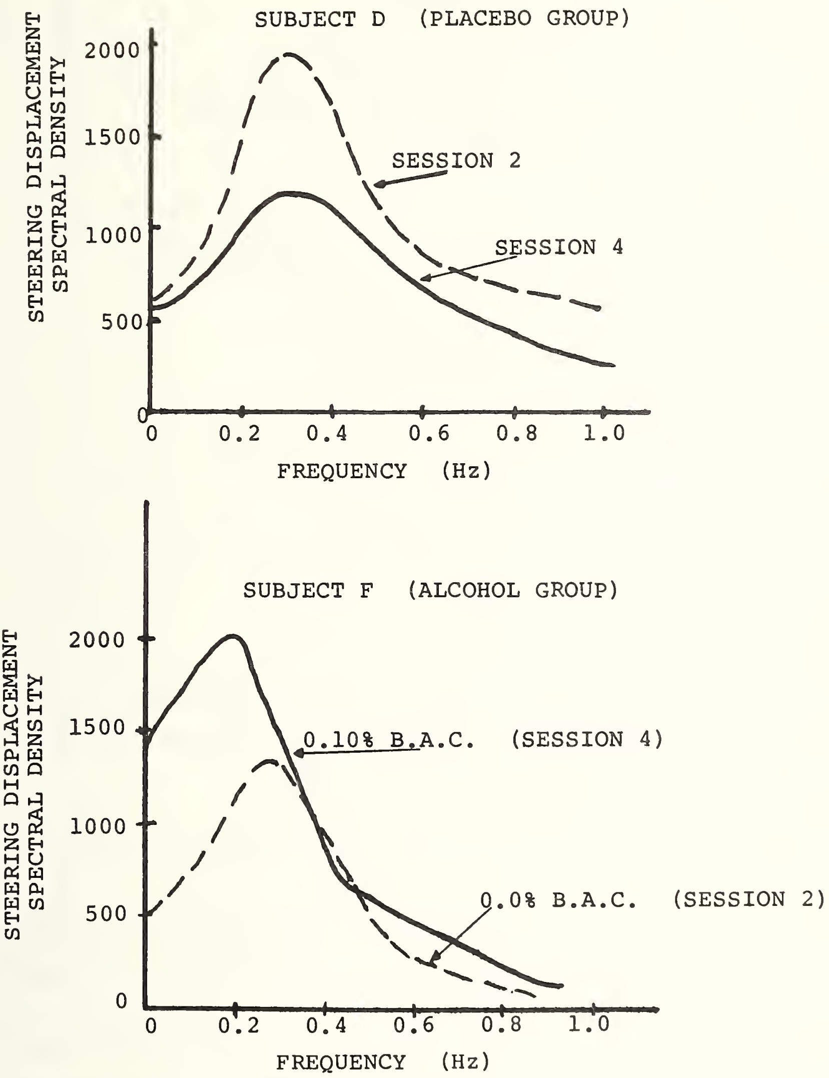


Figure 6 *Steering wheel displacement power spectra of a placebo and alcohol group subject in sessions 2 and 4.*

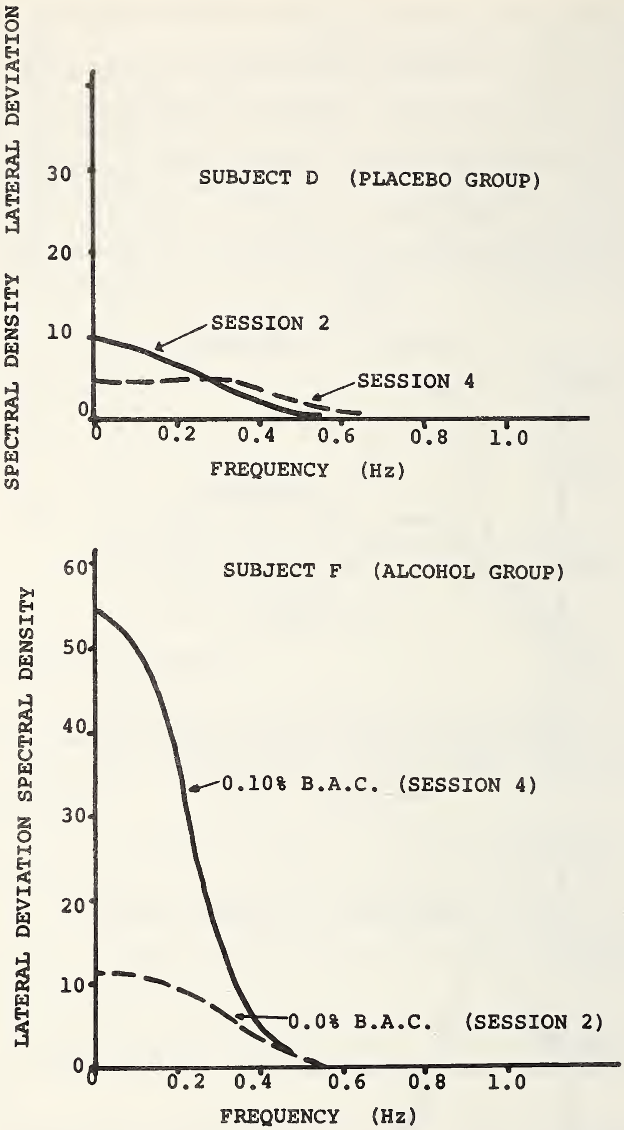


Figure 7 *Lateral position error power spectra of a placebo and alcohol group subject in sessions 2 and 4.*

Analyses of variance of the values of the frequency bandwidths showed that there were significant treatment group by session interactions for steering wheel displacement, path angle and yaw rate. Individual comparisons of means between treatment group, within sessions, showed:

1. The mean steering wheel displacement frequency bandwidth was reduced at 0.10% BAC and at 0.07% BAC in the elimination phase.
2. The mean path angle frequency bandwidth was reduced at all alcohol dose levels.

3. The mean yaw rate frequency bandwidth was reduced at all alcohol dose levels.

The means of the RMS values of the performance measures are shown in Figure 11.

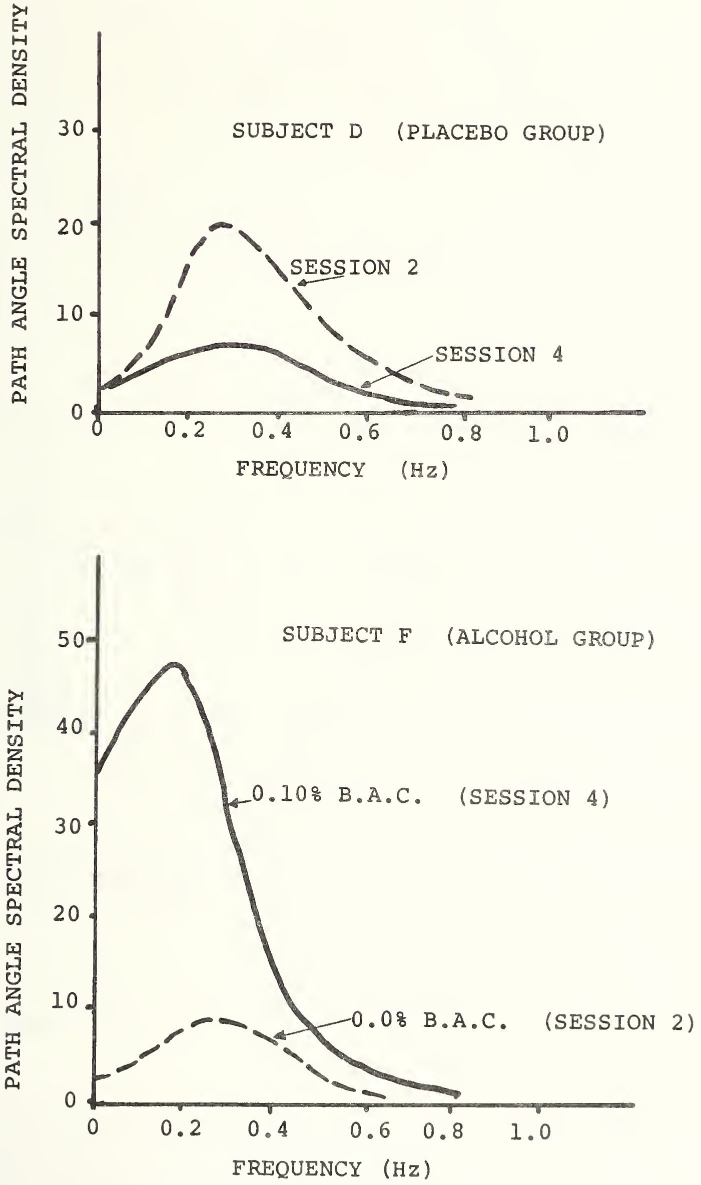


Figure 8 *Path angle power spectra of a placebo and alcohol group subject in sessions 2 and 4.*

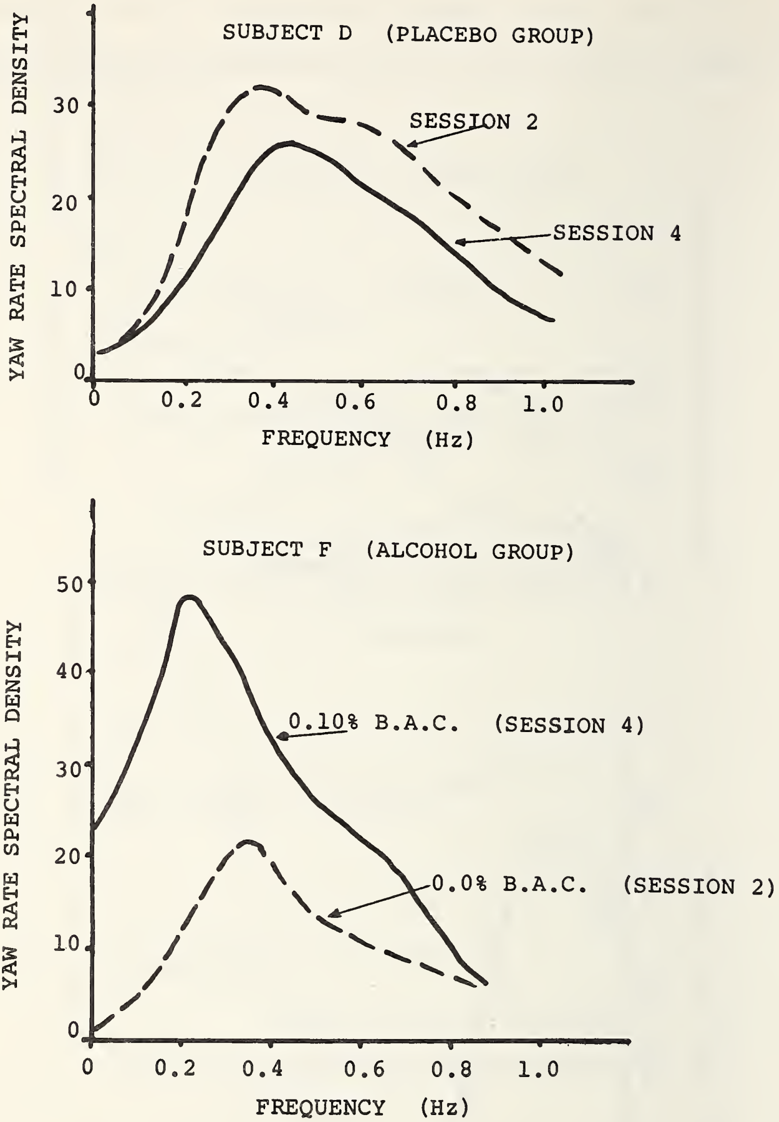


Figure 9 *Yaw rate power spectra of a placebo and alcohol group subject in sessions 2 and 4.*

Analyses of variance of the RMS values were made. Individual comparisons among means of these signals showed that:

1. Mean lateral position error RMS was increased at 0.10% BAC and at 0.07% BAC during alcohol elimination.
2. Mean path angle RMS was increased at 0.10% BAC and at 0.07% during alcohol elimination.

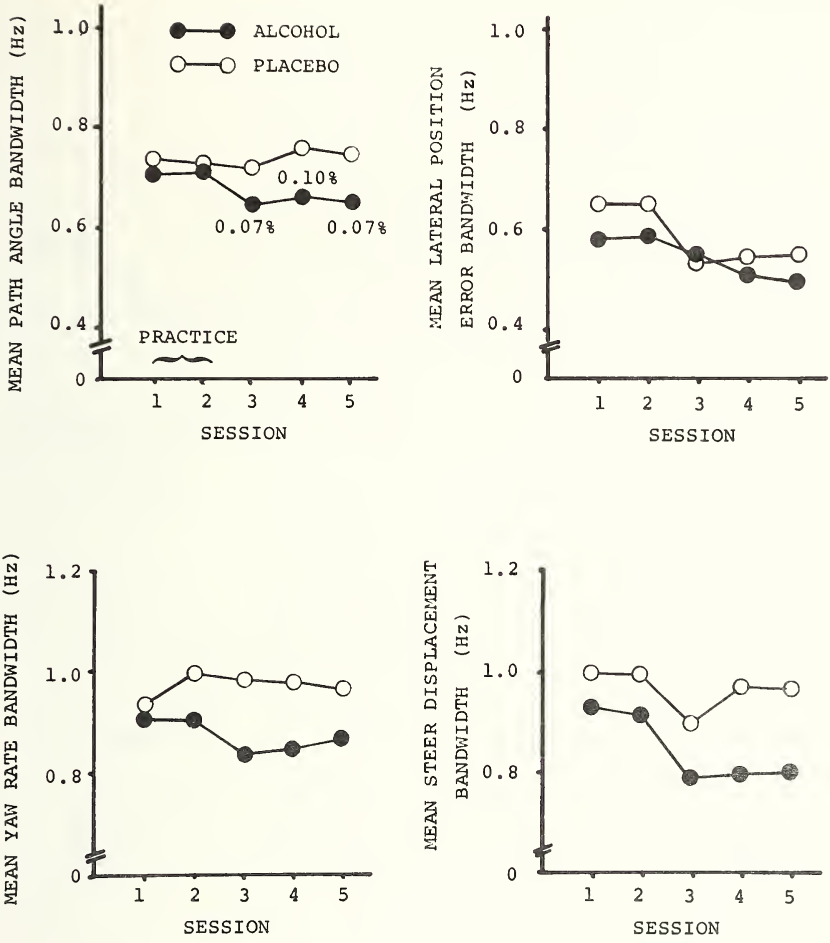


Figure 10 *Mean frequency bandwidths of performance measures in each session for eight subjects in the placebo and alcohol groups.*

DISCUSSION

That information processing is affected by alcohol has been amply demonstrated. The results have sometimes been used (17) to infer that studies that are conducted without overt subsidiary tasks should not expect to find effects of alcohol, or at least only minor ones. In addition, the same comment has been used to suggest that tracking tasks, with their demands on perceptual and motor skills, are probably not much affected by alcohol.

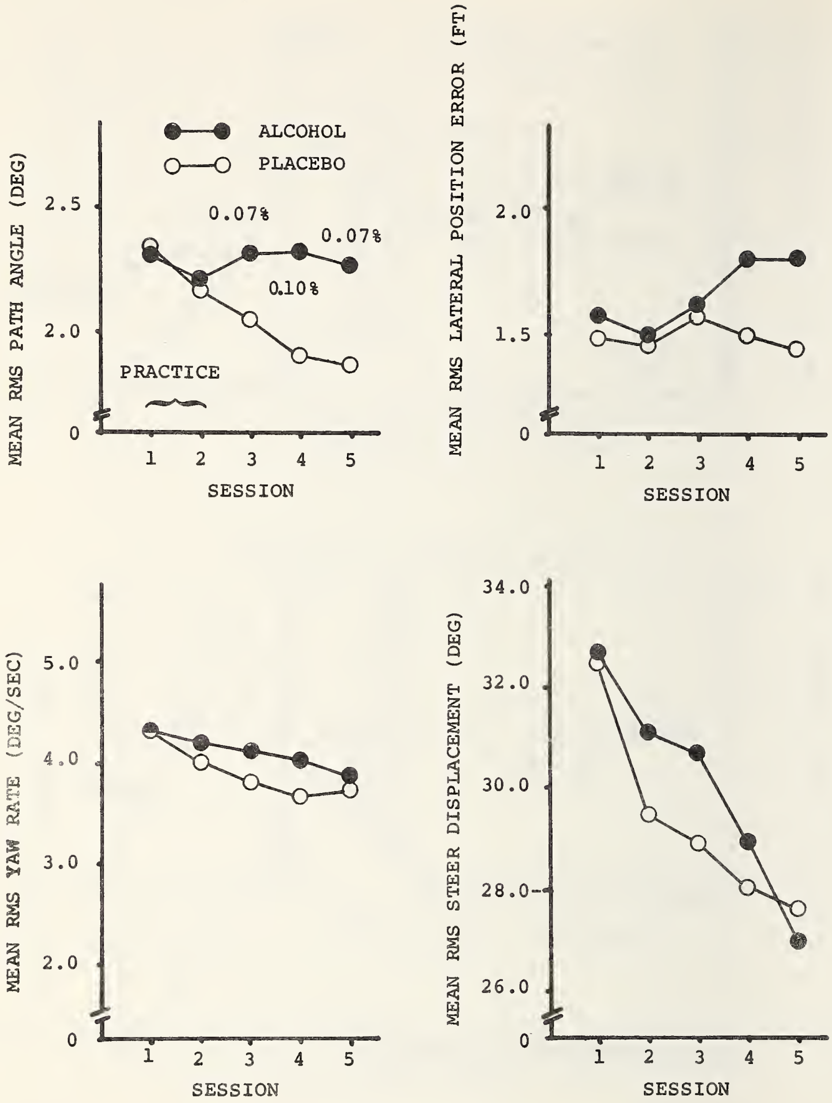


Figure 11 *Mean RMS of performance measures in each session for eight subjects in the placebo and alcohol groups.*

However, an argument can be made that the findings concerning the effects of alcohol on time-shared tasks are applicable to the driver's steering control task and that this should be affected by alcohol even when no overt subsidiary task is used. This is because the steering task has a number of components, which can be defined by the various elements (e.g., lateral position, path angle) of the cue structure used by drivers for safe vehicle control. Secondly, there is now sufficient evidence to indicate that when simulators were used in alcohol studies that have presented a display which resembles, in its basic elements, the road viewed by a driver, decrements in tracking performance were found at quite low BAC levels (5, 12). In addition, performance on a quite simple pursuit tracking task has also been impaired at low alcohol doses (26).

The present study indicates that low and moderate doses of alcohol do have an effect on the driver's steering performance, and provides additional information concerning those aspects of the driver's cue structure and response behavior which are affected by alcohol.

The frequency response analyses showed that there were significant reductions in steering wheel displacement frequency bandwidths at 0.10% BAC and 0.07% BAC in the elimination phase. Thus, drivers reduced their responsiveness under alcohol, as reported by Reed *et al* (21). The drivers' behavior in steering can therefore be considered to be more coarse, and similar to that of drivers in the early stages of the driving learning process. This is further shown by the decrease in the mean path angle and mean yaw rate frequency bandwidths, which were decreased in all the alcohol dose conditions. This shows that the drivers who received alcohol were not utilizing these perceptual cues to vehicle control as much as the placebo subjects. Since no significant changes were observed in the bandwidths of lateral position errors, this indicates that the drivers were utilizing this cue in much the same manner as without alcohol. The drivers who received alcohol, therefore, placed greater reliance on the lateral position error cue than path angle and yaw rate, compared to the drivers who did not receive alcohol.

This change in the cue structure used by drivers under alcohol resulted in an increase in the mean lateral position error RMS and mean path angle RMS at 0.10% BAC and at 0.07% BAC during alcohol elimination, showing that alcohol affected the ability of drivers to control the vehicle about the road lane.

While variability in lateral position error was increased in the last two alcohol sessions, it will be recalled that there was also an increase in the mean lateral position error of the drivers at 0.10% BAC, showing that they accepted a position in the lane that was further from the center of the lane.

In summary, these findings show that alcohol affected the cue structure used by drivers for path control of the vehicle. This is shown by a reduction in their sensitivity to yaw rate and heading angle cues, while they maintained emphasis on the lateral position cues. They became more sluggish in the use of the steering wheel as a means of reducing the perceived errors in the position of the vehicle they were controlling, as shown by a reduction in the bandwidth of steering wheel response frequencies under alcohol. This may have been a result of the greater emphasis that the alcohol subjects were placing upon the lateral position error cues. Since the lateral position error is the second integral of yaw rate and the first integral of path angle, the frequency response of a vehicle in lateral position can be expected to be less than in yaw rate or path angle. The reduction in steering wheel response frequencies may, therefore, be attributable either to the lower frequency cues presented to the driver by lateral position error or to a reduction in the driver's responsiveness. Thus, whether the driver's response behavior in steering under alcohol was a function of the perceptual cues that he acted on or a change in his motor responsiveness, cannot be inferred from these data.

The findings do show, however, that the drivers under alcohol changed their information processing strategy, as might have been expected based on studies carried out employing time-sharing tasks. While this study did not utilize an overt subsidiary task, the need for time-sharing in steering control is intrinsic to that task, in that the experienced driver will selectively utilize the elements of the cue structure available to him.

The basic vehicle control task is that of controlling the lateral position of the vehicle in the lane. It can be readily noticed that novice drivers interpret this task literally, by observing the low frequency steering motions they use and the large deviations which the vehicle they are controlling makes about the road. That lateral position error cues alone are quite inadequate for purposes of vehicle control has been experimentally evaluated by Mortimer (13) in an automobile driving task in which some of the cues presented to the driver could be isolated. Therefore, drivers learn to use additional cues, which are likely to be the path angle or heading angle and yaw rate (31).

The findings of this study indicate that the effect of alcohol on the driver's steering control task is fundamentally one of reducing his overall competence to a level more similar to that of novice drivers. The findings are also consistent with those of other studies which have shown changes in the manner in which subjects acquire information, with increasing emphasis being placed on the basic aspects of the task, which in respect to vehicle lateral control is the vehicle's lateral position in the lane. The study also sheds some light on reasons why, in some studies of tracking behavior, there were not decrements in performance attributable to alcohol. Where the pursuit components of a tracking task are not available to subjects, who are therefore faced with pure compensatory tracking, information such as heading angle is not available, so that the cue structure used by subjects is unidimensional, consisting of position error and, hence, is more resistant to impairment by alcohol. This study also showed that there was generally more indication of impairment in the alcohol elimination phase than at the equivalent BAC level during alcohol uptake, suggesting residual effects of alcohol or interactions with temporal variables, such as fatigue.

The findings of this study are consistent with theories of manual control and are a first step to explanations for the perceptual and motor mechanisms underlying loss-of-control crashes involving alcohol.

REFERENCES

1. Belt, B. L., Driver Eye Movement as a Function of Low Alcohol Concentrations, Driving Research Laboratory, The Ohio State University, Columbus, Ohio, 1969.
2. Bjerver, K. and Goldberg, L., Effect of Alcohol Ingestion on Driving Ability: Results of Practical Road Tests and Laboratory Experiments, *Quarterly Journal of Studies on Alcohol* 2, 1-30 (1950).
3. Case, H. W., Hulbert, S. and Moskowitz, H., Alcohol Level and Driving Performance, University of California at Los Angeles, Report No. UCLA-ENG-71-17, 1971.
4. Cohen, J., Dearnally, E. J. and Hansel, C.E.M., The Risk Taken in Driving Under the Influence of Alcohol, *British Medical Journal* III, 1438-1442 (1958).
5. Drew, G. C., Colquhoun, W. P. and Long, H. A., Effect of Small Doses of Alcohol on a Skill Resembling Driving, *British Medical Journal* II, 993-999 (1958).
6. Filkins, L. D., Clark, C. D., Rosenblatt, C. A., Carlson, W. L., Kerlan, M. W. and Manson, H., Alcoholism Abuse in Traffic Safety: Study of Fatalities, DWI Offenders, Alcoholics, and Court-Related Treatment Approaches, Final Report, Contracts FH-11-6555, FH-11-7129, U.S. Department of Transportation, Highway Safety Research Institute, University of Michigan, 1970.
7. Griep, D. J., *Alcohol and Road Safety.* Institute for Road Safety Research (SWOV), 1968.
8. Hamilton, P. and Copeman, A., The Effect of Alcohol and Noise on Components of a Tracking and Monitoring Task, *British Journal of Psychology* 61, 149-156 (1970).

9. Huntley, M. S., Effects of Alcohol and Fixation-Task Demands Upon Human Reaction Time to Accromatic Targets in the Horizontal Meridian of the Visual Field, Doctoral Dissertation, University of Vermont, 1970.

10. Jordan, J. J., Alcohol and Traffic Safety: A Survey of Canadian Research, Traffic Injury Research Foundation of Canada, 1971.

11. McCarroll, J. R. and Haddon, W., A Controlled Study of Fatal Automobile Accidents in New York City. *Journal of Chronic Diseases* **15**, 811-826 (1962).

12. Mortimer, R. G., Effect of Low Blood-Alcohol Concentrations in Simulated Day and Night Driving, *Perceptual and Motor Skills* **17**, 399-408 (1963).

13. Mortimer, R. G., Driving with a CRT Display, *Perceptual and Motor Skills* **25**, 899-900 (1967).

14. Mortimer, R. G., Filkins, L. D. and Lower, J. S., Development of Court Procedures for Identifying Problem Drinkers: Final Report, Highway Safety Research Institute, University of Michigan, Report No. HuF-11, (PB209958), 1971.

15. Mortimer, R. G. and Jorgeson, C. M., Eye Fixations of Drivers as Affected by Highway and Traffic Characteristics and Moderate Doses of Alcohol, Proceedings: 16th Annual Meeting of the Human Factors Society, October 1972.

16. Moskowitz, H. and DePry, D., The Effect of Alcohol on Auditory Vigilance and Divided Attention Tasks, *Quarterly Journal of Studies on Alcohol* 29, 54-63 (1968).

17. Moskowitz, H., The Effects of Alcohol on Performance in a Driving Simulator of Alcoholics and Social Drinkers, University of California at Los Angeles, Report No. UCLA-ENG-7205, 1971.

18. Moskowitz, H. and Burns, M., The Effect of Alcohol on the Psychological Refractory Period, *Quarterly Journal of Studies on Alcohol* 32, 782-790 (1971).

19. Moskowitz, H. and Sharma, S., Effects of Alcohol on Peripheral Vision as a Function of Attention, *Human Factors* **16**, 174-180 (1974).

20. Perrine, M. W. and Huntley, M. S., Influences of Alcohol Upon Driving Behavior in an Instrumented Car, University of Vermont, Report No. DOT-HS-800-625, 1971.

21. Reed, L. D., Ibrahim, M.K.F., Miller, R. D. and Hansteen, R. W., The Influence of Alcohol and Marijuana on a Manual Tracking Task, *Society of Automotive Engineers,* Report No. 730092 (1973).

22. Road Research Laboratory. *Research on Road Safety,* HM Stationary Office, London, 1963.

23. Schmidt, W. S. and Smart, R. G., Alcoholics, Drinking and Traffic Accidents, *Quarterly Journal of Studies on Alcohol* **20**, 631-644 (1959).

24. Snapper, K. and Edwards, W., Effects of Alcohol on Psychomotor Skill and Decision-Making in a Driving Task, Report on Grant No. MH22063-01, University of Michigan, 1973.

25. Sturgis, S., Effects of Practice and Alcohol on Two Psychomotor Tasks: Implications for an Automobile Alcohol Ignition Interlock, Unpublished Masters Thesis, Eastern Michigan University, 1972.

26. Sturgis, S. and Mortimer, R. G., Effects of Practice and Alcohol on Selected Skills: Implications for an Automobile Alcohol Ignition Interlock, *Perceptual and Motor Skills* 37, 267-274 (1973).

27. Sussman, D. E. and Abernathy, C. N., Laboratory Evaluation of Alcohol Safety Interlock Systems, U.S. Department of Transportation, Report No. DOT-HS-800-925, 1973.

28. Voas, R. B., Factors Related to Alcohol Involvement in Crashes, Proceedings: First International Conference on Driver Behavior, IDBRA, Zürich, October 1973.

29. Waller, J. A., Accident Patterns Associated With Drinking and Violations Among Drivers With Alcoholism, Other Medical Conditions, and No Medical Conditions, In: Report of the Secretary's Advisory Committee on Traffic Safety, Department of Health, Education, and Welfare, Washington, D.C., 1968.

30. Wallgren, H. and Barry, H., *Actions of Alcohol Volume I, Biochemical, Physiological and Psychological Aspects,* Elsevier Publishing Company, New York, 1970.

31. Wier, D. H. and McRuer, D. T., Measurement and Interpretation of Driver/Vehicle System Dynamic Response, *Human Factors* **15**, 367-378 (1973).

Vehicle-Borne Drunk Driver Countermeasures

R. R. Thompson[1], Jean A. Tennant and B. S. Repa

In many areas of society, the effects of alcohol abuse are subtle and often difficult to quantify. In the area of motor vehicle transportation, however, the effects are highly evident and can be quantified by the number of fatalities, injuries, and the economic losses caused by the misuse of alcohol. While precise figures indicating the extent to which alcohol is the causative agent in accidents are difficult to obtain, it is estimated to be a contributory factor in more than half of the motor vehicle accidents (1, 4). Because of the scope of the problem and the fact that it is an increasing one, General Motors has been exploring potential solutions through an alcohol countermeasures program.

One aspect of this program involves efforts in the area of education where attempts are being made to inform the public of the scope of the alcohol problem through radio announcements, pamphlets, films, and exhibits, as well as to stress personal responsibility in the use of alcohol at all times.

Another aspect of the program represents an engineering approach to the problem; namely, an attempt to develop a vehicle-borne system for detecting driver impairment (3). The different categories of systems that have been considered are firstly, pre-driving tests consisting of breath alcohol analysis and performance testing; and secondly, continuous performance monitoring consisting of psychophysiological parameters and driver performance parameters. Pre-driving tests attempt to identify impairment *prior* to driving and once it is identified, to inhibit the operation of the vehicle. The detection process can be based on a performance test or on chemical analysis of a breath sample (3, 8). The continuous monitoring techniques attempt to identify impairment while the vehicle is being operated. They are based either on some aspect of driving performance or some measure of psychophysiological condition. Warning systems would be activated upon identification of impairment.

Some of the advantages and disadvantages of each of these approaches are shown in Tables I and II. Pre-driving tests offer the opportunity to safely inhibit operation of the vehicle if impairment is identified. On the other hand, continuous monitoring approaches do not burden the driver with any additional tasks and can be based on longer samples of data. They can also detect impairment whose onset occurs after the vehicle is in operation. The continuous monitoring approaches are at a very early stage of development, however. In the pre-driving test category, breath analysis techniques have received wide support because of their correlation with the legal criterion for intoxication, namely, a given percentage of alcohol in the blood. Performance tests, on the other hand, are based on a functional rather than a chemical identification process. Since it is well recognized that the degree of impairment associated with a given BAC level varies widely among individuals, it is reasonable and defensible to attempt to detect impairment with a behavioral rather than a chemical test.

---

[1] Engineering Mechanics Department Research Laboratories, Warren, Michigan 48090, U.S.A.

While benefits can be expected from each of these approaches, General Motors has placed most of its effort on pre-driving performance tests because of their relative ease of implementation and promise of more immediate impact. The remainder of this paper will deal with this category of alcohol countermeasures.

TABLE I *Advantages and Disadvantages of Pre-Driving Tests*

Breath Tests

Advantages

- Breath sample relatively easy to obtain
- Based on legal definition of alcohol intoxication

Disadvantages

- Could be easy to fool unless made more complicated and discriminating
- Limited to alcohol impairment
- Present devices do not lend themselves readily to rapid automatic operation nor to low maintenance schedules

Performance Tests

Advantages

- Directly sensitive to degradation in psychomotor performance
- Sensitive to degrading effects of factors such as drugs, illness, fatigue, as well as alcohol
- Not easily defeated by mechanical devices
- Can be made durable and tamper resistant

Disadvantages

- Require some training to be effective
- May measure performance levels idiosyncratic to each driver
- Short test length may be detrimental to reliability

REVIEW OF PRE-DRIVING PERFORMANCE TESTS

Objectives and Desired Characteristics

In order for a pre-driving performance test to be effective as an alcohol ignition interlock[2], it must meet the following objectives:

1. Large discrimination against intoxicated individuals (positive rejection rates).
2. No discrimination against sober individuals capable of driving (false rejection rates).

---

[2] An alcohol ignition interlock is a device designed for installation in an automobile to automatically determine if the driver is intoxicated and to prevent operation of the vehicle when intoxication is detected.

TABLE II *Advantages and Disadvantages of Continuous Monitoring Systems*

Driver Performance Monitoring

Advantages

- Sensitive to variable of prime interest, driving performance
- Does not burden driver with any additional tasks
- Sensitive to all forms of impairment
- Would catch drivers who become impaired after starting to drive

Disadvantages

- Requires more clearly established base line for normal performance than is presently available

Physiological Monitoring

Advantages

- Based on detection of physiological concomitant of impairment and, therefore, hard to fool
- Sensitive to all forms of impairment
- Would catch impairment whose onset occurs while driving

Disadvantages

- Incomplete knowledge of physiological correlates of impairment
- Present laboratory measures have not been reduced to practical application

While most programs to date were conducted primarily with the goal of quantifying individual test sensitivities to BAC by assessing the above rejection rates, the following additional characteristics are desired and must be considered in any comparative analysis: high correlation with driving ability; short duration of test; rapid learning rate; easy integration in vehicle; insensitivity to age, sex, intelligence, and social and educational backgrounds; not easily compromised; low cost.

Effectiveness Level

There are two approaches which can be taken in setting the test parameters for most pre-driving behavioral tasks used as alcohol interlocks. One may use a single level of performance (Universal Threshold) as a requirement for the total driving population or use a level determined by the capability of each driver (Individual Threshold) (20). In some cases, the nature of the test determines the criterion which must be used. In those cases where the type of test permits the use of either criterion, greater effectiveness in detecting impaired behavior will be attained by using an Individual Threshold since it reduces the variability between individuals. Implementing this criterion for the entire driving population would be a difficult if not impossible task. However, if alcohol ignition interlocks are court ordered for convicted offenders only, then the procedure of individualizing the performance level for starting a vehicle is feasible.

The Phystester

The first significant effort in the application of modern technology to deny the drunk driver the use of his vehicle was the development of the Phystester by General Motors. While providing the main impetus for the initiation of programs by government and private organizations to counteract the major cause of accidental death, the Phystester program also provided a tremendous amount of heretofore unavailable and much needed information.

Universal threshold approach. Although individual performances on the Phystester were significantly correlated with both BAC and performance on a simulated driving task, the alcohol test results using a universal threshold criterion indicated that while the Phystester is capable of discriminating between sober and intoxicated individuals, the debilitating effects of alcohol are not large enough to eliminate more than 50 per cent of the drivers at BACs of 0.1% without also eliminating a large number of sober drivers (12).

In addition to our own tests conducted at the William Beaumont Hospital (12), the Phystester was tested extensively by the Medical College of Wisconsin (MCOW) (9), Cornell Aeronautical Labs (CAL) (18) and Systems Technology, Inc. (STI) (7) with similar results. For example, MCOW rated the effectiveness of the hand-held Phystester (using a five-digit display with 3.5 seconds response time) to be in the 30 per cent range. Better effectiveness was predicted if only the first three trials were used. Effectiveness in this study was defined as:

$$E = \frac{(\%\text{ sober passes})^2 \times (\%\text{ drunk failures})}{10{,}000}$$

Using this definition, STI results showed a maximum effectiveness of 25 per cent (five-digit 3.5 seconds response time) when BAC was 0.1%. There was no significant change when three trials were used. Cornell results for a representative group of subjects in the 0.15% BAC range showed a maximum effectiveness of 53 per cent, although at this response time (3.0 seconds) the sober failure rate was 4 per cent. With a 3.2 seconds response time, the sober failure rate was reduced to 0.6 per cent, but the effectiveness was then reduced to about 20 per cent. The large variability in performance observed among sober subjects is the main factor limiting effectiveness.

Individualized threshold approach. A significant increase in intoxicated failure rates was observed when the response time of the primary task was individualized to each subject so that given three trials a 1 per cent sober failure rate was assured (14). The drunk failure rate obtained from 15 subjects who exceeded 0.10% BAC was 35 per cent. For six subjects who exceeded 0.15% BAC, the failure rate was increased to 41 per cent. These results were obtained for three allowed trials in which to obtain one pass. More sensitivity was noted during the rising BAC phase than during the descending phase. These results are summarized in Table III.

TABLE III *Failure Rates for the Phystester using Individualized Response Times*[a]

BAC (g/100ml)	No. of Subjects	Failure Rate
0	20	1
⩾.05	20	20
⩾.10	15	35
⩾.125	11	36
⩾.150	6	41

[a] Pass Criterion = 1:3

Other Devices and Tests Evaluated

A review of alternative devices tested by the Department of Transportation's Transportation Systems Centre (TSC) (15) shows that those listed below are apparently no more effective than the Phystester.

Device	*Effectiveness*
Compensatory Tracker (TSC)	23%
Complex Reaction Time (TSC)	22%
Quick-Key (Smith)	35%

Other studies were conducted by the Medical College of Wisconsin (9), Ohio State University (17), and the Cornell Aeronautical Laboratories (18) to evaluate both applicable devices and sensitive behavioral mechanisms upon which a device could be based. All the tests measure sensory, cognitive, or motor behavior.

Analyses of these approaches and of the results obtained to date led us to the conclusion that the most promising tasks would be ones that require: a) high concentration; b) simultaneous information processing; and c) rate perception.

Consequently, General Motors developed a second generation alcohol ignition interlock based on the *critical task concept* (10). This task forces high workloads on the driver, since it is inherently unstable without the subject in the loop. By varying the controlled element properties, the driver's time delay or rate perception capabilities can be tested. In both a laboratory test environment and under simulated field test conditions, this second-generation development has proved more effective than any other experimental interlock system tested or developed to date by General Motors and is discussed in the following section.

THE CRITICAL TRACKING TASK (CTT) AS AN ALCOHOL INTERLOCK SYSTEM

Task Description

The task requires the operator to stabilize the output of a dynamically unstable system whose level of instability (or degree of difficulty) increases with time. The error is displayed visually to the operator whose task is to cancel the error by manipulating a control. When the level of difficulty reaches a point where the operator can no longer compensate for the error, the test is terminated.

The test is easy at first. Gradually it becomes more difficult, resembling somewhat the steering of a car on a slippery surface, such as ice, while the speed of the car gradually increases (without the driver's control). It involves controlling an unstable system which gradually becomes more unstable. In the analogy of driving a car on ice, it is obvious that as speed increases, the system becomes more unstable and its control becomes more demanding. If the speed is increased indefinitely, control will eventually be lost. The performance index or score is the speed at which control is lost. The higher this critical level of instability (the higher the critical speed), the higher the score.

Figure 1 illustrates what takes place when the driver performs the task. At initiation of the test, the output of the controlled element (y_c) starts to diverge from the reference, since the system is unstable. The operator (y_p), sensing the error, controls the output by means of steering wheel corrections. As the test proceeds, the "autopacer" changes the dynamic characteristics of the controlled element, making them more unstable.

Interesting correlations between performance on the CTT and neuromuscular time delays have been established in man/machine related research (10). In particular, it was discovered that the constraint of the task on the operator's dynamic behavior provides for accurate estimations of the operator's effective time delay[3]. This observation could indicate that performance on the task is not solely a measure of motor responses but may also involve higher neural functions since the effective time delay is influenced by central processing delays, neuromuscular delays, and the subject's ability to anticipate the consequences of his own responses. It was anticipated, therefore, that performance on the task would show significant degradation when conducted by a person in an unfit or intoxicated state. A well-validated background of applications and statistical data exists for the Critical Tracking Task. Applications have included both acute and chronic drug studies (2, 16) and investigations of the effects of environmental stress on human performance (5, 19).

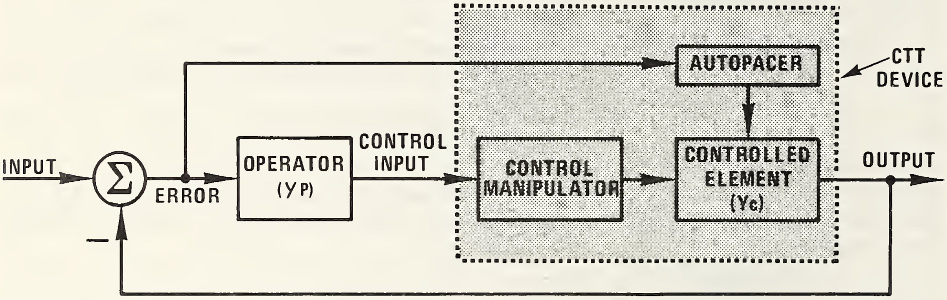


Figure 1 *Block Diagram Representation of CTT.*

The motivation and roots of the development of this task originate in the fields of handling qualities and engineering psychology. Notable among this research is the investigation of manual control of a statically unstable, inverted pendulum using visual and/or motion cues (21), and the review of several concepts of "self-paced" tracking tasks by Kelly (13). Perhaps the most pertinent related work is that by Chernikoff and Birmingham (6), wherein a parameter governing the dynamic response of the system to be controlled is varied, and its limiting value is used to measure some aspect of the operator's tracking skill.

Task Mechanization

Evidence that the level of task difficulty at which control can no longer be maintained differs significantly in the normal and intoxicated states was first obtained in a laboratory test environment using an oscilloscope to display the system error and an isometric force stick as the control manipulator (20). The results from the study suggested that the CTT had the potential for being an effective pre-driving test for impairment if it could be mechanized effectively in the vehicle.

---

[3] The reciprocal of λ_{cr} (the value of λ at which control is lost) corresponds to the subject's effective time delay.

Subsequently, a vehicle configuration of the CTT was developed. For vehicle use, the steering wheel and a meter were substituted for the force stick and the oscilloscope used in the initial evaluation. Although the basic concept of the task remained unchanged, differences in the dynamic characteristics of the Driver/CTT system were apparent. While the laboratory unit required only small movements of the fingers and wrist, the vehicle unit required larger motions of the hands and arms. Consequently, large neuromuscular lags and hardware lags were introduced into the task. Because of these fundamental differences, it was inappropriate to assume that the level of effectiveness obtained from the laboratory evaluation would be the same for the vehicle system.

AN EXPERIMENTAL PROGRAM USING THE CCT

Objectives

Because of the differences in task dynamics between the laboratory and vehicle units as well as the type of training procedure used in the laboratory evaluation, the goals of the program were to establish the level of effectiveness of the vehicle CTT using more realistic training conditions, in both frequency of use and environment, by providing subjects with cars equipped with the CTT units, and to compare the level of effectiveness obtained with that found in the laboratory evaluation.

In the laboratory evaluation of the Critical Tracking Task, the training procedure consisted of two practice sessions separated by a two-week interval. A total of 30 practice trials were taken on the first day and 20 trials on the second day followed by 10 test trials in the intoxicated state.

A second area of interest was whether differences in task performances exist related to subject differences in age, sex and education.

The performance criterion used in determining the percentage of intoxicated failures in the laboratory evaluation was based on a single level of performance which was applied to the total subject population (Universal Threshold). To permit comparisons in this report with the data obtained from the laboratory evaluation, the same data format and criterion are used. Other analyses of the data using the individual criterion (Individual Threshold) are presented to determine if significant improvements in effectiveness can be attained using this procedure.

Method

Subjects. Seventy-one subjects (45 males and 26 females) ranging in age from 18 to 51 years participated in the study. The subjects were primarily a cross-section of the employees of a local hospital where the study was conducted.

An attempt was made to select subjects so that a wide range of occupations, educational levels, and ages would be represented in the subject population. The screening and selection of the participants were made by medical personnel at the hospital based on a review of the subjects' medical history. Volunteers with medical problems which would be aggravated by the ingestion of alcohol or those under medication which was incompatible with alcohol were not permitted to participate in the program.

Training/testing. The evaluation program was conducted in cooperation with the hospital staff and used its facilities for the training and testing of subjects. An area in the administrative section of the hospital was provided for the program and was arranged to convey an informal, relaxed atmosphere. Subjects were permitted to read newspapers and magazines or otherwise occupy themselves during the waiting periods in the training and test sessions.

The training and testing schedule required a period of 11 days for each subject. On the first day the subject was familiarized with the CTT and given 25 training trials on a simulator instrumented with the device. Following the training, the subject was assigned a vehicle instrumented with the CTT which functioned as an ignition interlock system. Ten trials were given on the vehicle to ensure that the subject could meet the level of task difficulty required for starting the vehicle. The subject was instructed to use the vehicle as his own for the next 10 days and whenever operating the task to continue each time until control could no longer be maintained.

On the 11th day, the subject returned for the test session. A Breathalyzer was given upon arrival and was followed by five trials in the vehicle and five trials on the simulator. Four drinks were next administered evenly spaced in an 80-minute period. Forty minutes after completing the fourth drink the subject was given a Breathalyzer test and taken to the vehicle. Five trials were given on the vehicle unit. The subject was then returned to the test room and received five trials on the simulator followed by a second Breathalyzer test.

CTT Parameters. Identical task parameters were used on the simulator and vehicles during the evaluation program. These parameters are:

1) λ_{1C} = initial level of stability
2) $\dot{\lambda}$ = rate of change in stability
3) λ_T = threshold level required for starting vehicle

The settings of these task variables on the simulator and vehicles were checked during each training and test session.

Alcohol Administration. The alcohol given to the subject during the drinking phase was 100 proof vodka and was mixed with either orange or tomato juice. The total volume of vodka administered was calculated on the subject's weight and a summary of the amount and frequency of his drinking. Based on the summary, the subject was categorized as one of the following and scheduled to receive the corresponding volume of vodka indicated:

Light Drinker	– 2.2 ml/kg body weight
Average Drinker	– 2.75 ml/kg body weight
Above Average Drinker	– 3.3 ml/kg body weight

The alcohol was administered by a physician and adjustments were made as necessary during the drinking period in the amount of vodka administered to compensate for nausea reported by the subject, excessive behavioral impairment or the lack of signs of intoxication.

The Breathalyzer measurements were taken by a trained operator, and the instrument was checked for calibration at the end of each session.

Results

Table IV presents the failure rate obtained at increasing levels of λ (task difficulty) and trial criteria for the unimpaired state (0% BAC) and at increasing levels of impairment (≥ 0.09% to ≥ 0.15% BAC). As shown, under 1 Pass out of 3 Trial requirements, no failures occur at 0% BAC up to a level of difficulty of $\lambda_T = 4.2$. The corresponding failure rate for the impaired states ranges from 76.5% for BACs ≥ 0.09% to 83.4% for BACs ≥ 0.15%.

Table V presents the comparable data obtained on the laboratory CTT unit used in the previous evaluation.

TABLE IV *Failure Rate Obtained at Increasing Levels of Task Difficulty (Vehicle CTT System)*

	Criterion		Blood Alcohol Concentration (g/100ml)							
Universal Criterion	Passes Required	Trials Allowed	0	≥.09	.10	.11	.12	.13	.14	.15
4.1	1	1	23.0	87.0	89.0	87.0	86.0	83.0	88.0	83.0
	2	3	23.0	8.0	86.0	83.0	83.0	83.0	83.0	93.0
	1	2	7.0	73.0	75.0	74.0	72.0	75.0	77.0	75.0
	1	3	0.0	67.0	67.0	67.0	66.0	71.0	71.0	75.0
4.2	1	1	25.0	91.0	94.0	91.0	92.0	92.0	94.0	92.0
	2	3	27.0	84.0	86.0	85.0	86.0	86.0	88.0	92.0
	1	2	7.0	79.0	81.0	80.0	80.0	83.0	82.0	83.0
	1	3	0.0	76.0	78.0	78.0	80.0	83.0	82.0	83.0
4.3	1	1	38.0	94.0	95.0	94.0	94.0	92.0	94.0	92.0
	2	3	41.0	68.0	91.0	89.0	89.0	92.0	94.0	92.0
	1	2	20.0	87.0	89.0	89.0	89.0	92.0	94.0	92.0
	1	3	11.0	81.0	83.0	83.0	86.0	86.0	88.0	92.0
		Number of Subjects	71	67	63	46	35	24	17	12

Again, no failures occur at 0% BAC up to a λ level of 4.2. However, the corresponding failure rate for BACs ≥ 0.10% is approximately 30 per cent lower than that found with the vehicle units. Additional comparisons at increasing levels of BAC show consistently lower failure rates for the laboratory results up to the ≥ 0.15% level. Here the failure rate is 100 per cent for the four subjects at that level. The failure rate at the BAC level ≥ 0.15% in the present study was 83.4 per cent for the 12 subjects who reached that level.

The resulting failure rates obtained using the Individual Threshold criterion are compared against those obtained using the Universal Threshold criterion ($\lambda = 4.2$ with a 1 Pass out of 3 Trial required) in Figure 2.

To determine an individual threshold, the highest and lowest score of the five Pre-Drink trials were discarded and the mean of the remaining three scores was computed for each subject. The first three trials following the drinking period were then compared to this value to compile the failure rates.

TABLE V *Failure Rate Obtained at Increasing Levels of Task Difficulty (Laboratory CTT System)*

	CRITERION		BLOOD ALCOHOL CONCENTRATION (g/100ml)					
UNIVERSAL THRESHOLD (λr)	Passes Req'd	Trials Al-lowed	0	⩾.10	.12	.13	.14	.15
4.0	1	1	3.0	62.5	66.7	75.0	81.8	100
	2	3	1.5	55.0	62.5	75.0	81.8	100
	1	2	0	50.0	54.2	62.5	72.7	100
	1	3	0	42.5	50.0	56.3	63.6	100
4.2	1	1	13.4	72.5	75.0	81.3	81.8	100
	2	3	4.5	65.0	70.8	81.3	90.0	100
	1	2	3.0	60.0	66.7	75.0	81.8	100
	1	3	0	47.5	58.3	68.8	72.7	100
4.4	1	1	16.4	75.0	79.2	87.5	90.9	100
	2	3	11.9	67.5	75.0	87.5	90.9	100
	1	2	7.5	65.0	75.0	87.5	90.9	100
	1	3	3.0	62.5	70.8	87.5	90.9	100
	Number of Subjects		67	40	24	16	11	4

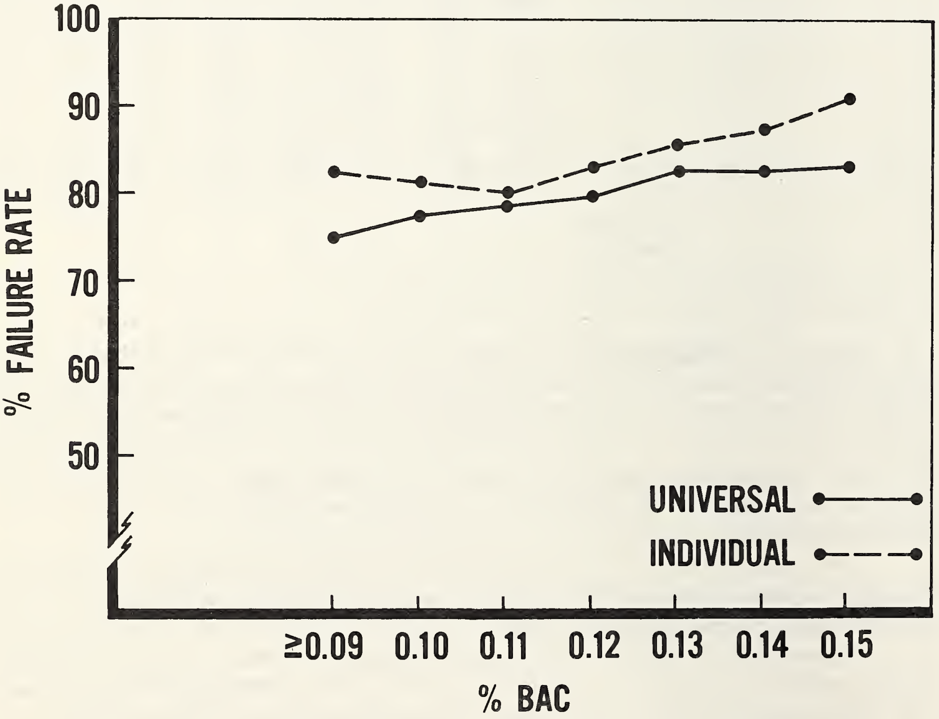


Figure 2 *Universal Threshold and Individual Threshold Failure Rates of All Subjects.*

As shown, the failure rates for the Individualized Thresholds range from 82.4 per cent for BACs ⩾ 0.09% to 91.7 per cent for BACs ⩾ 0.15%. Compared to the failure rates using the Universal Threshold, slightly greater effectiveness is found using the Individual Threshold criterion.

Age differences. Figure 3 shows the failure rates of those under 30 years and those over 30 years of age for the Universal Criterion analysis. In general, the under 30 year age group shows lower failure rates under the various BAC levels.

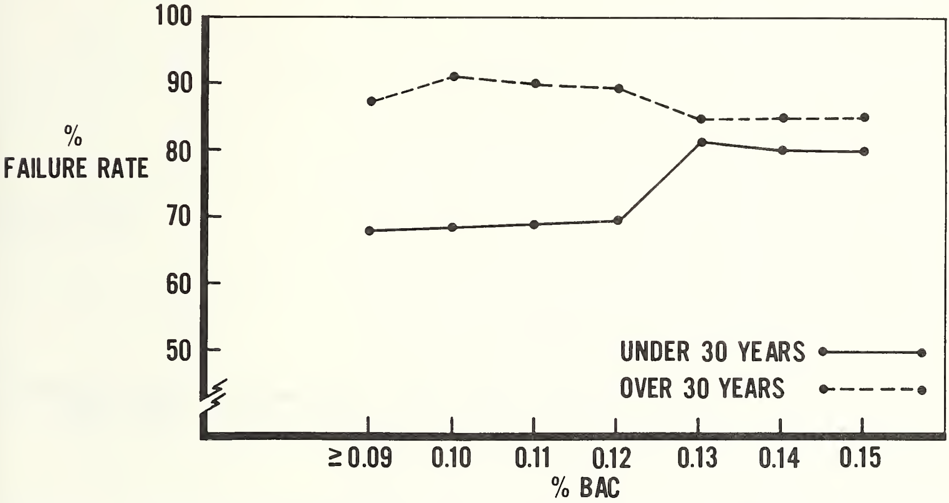


Figure 3 *Universal Threshold Failure Rates of the Over 30 Years and Under 30 Years Age Groups.*

A similar pattern is shown in Figure 4 which shows the failure rates of the two groups using the Individual Threshold criterion.

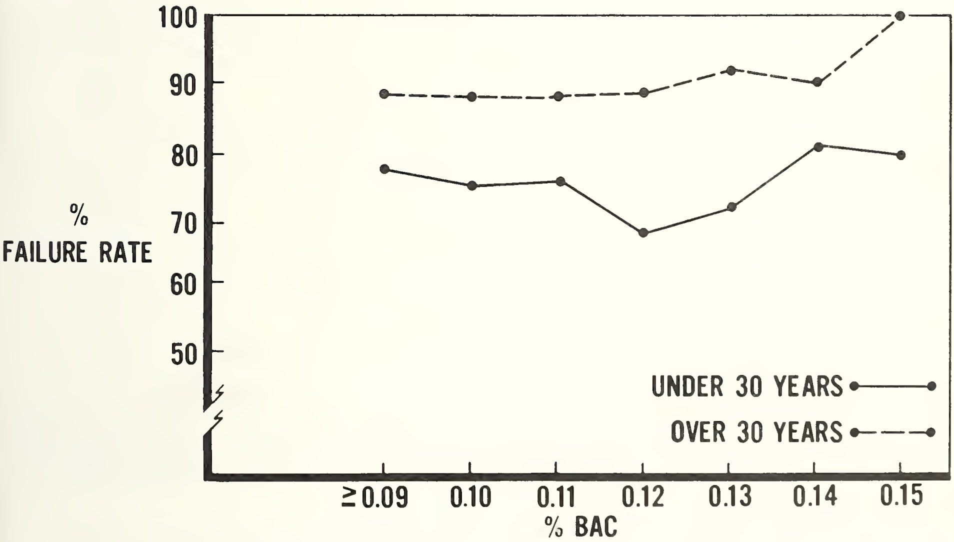


Figure 4 *Individual Threshold Failure Rates of the Over 30 Years and Under 30 Years Age Groups.*

Lower failure rates are again shown for the under 30 year group at every BAC level.

Male and female task performances. Figure 5 shows the sober and intoxicated failure rates for the male and female subjects, using the Universal Threshold. For low BAC levels, the data show a slightly lower failure rate for the male subjects. Meaningful comparisons at the higher BAC levels (⩾0.13%) are impossible due to the low number of female subjects who reached that level (N = 2).

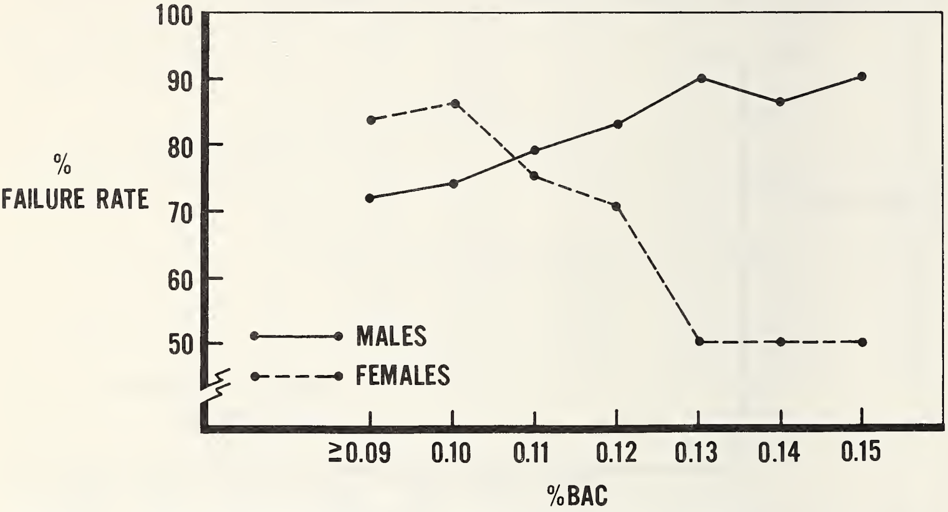


Figure 5 *Universal Threshold Failure Rates of the Male and Female Groups.*

A comparison of failure rates of the two groups for the Individual Threshold analysis is shown in Figure 6. Here the overall performance of the two groups is similar.

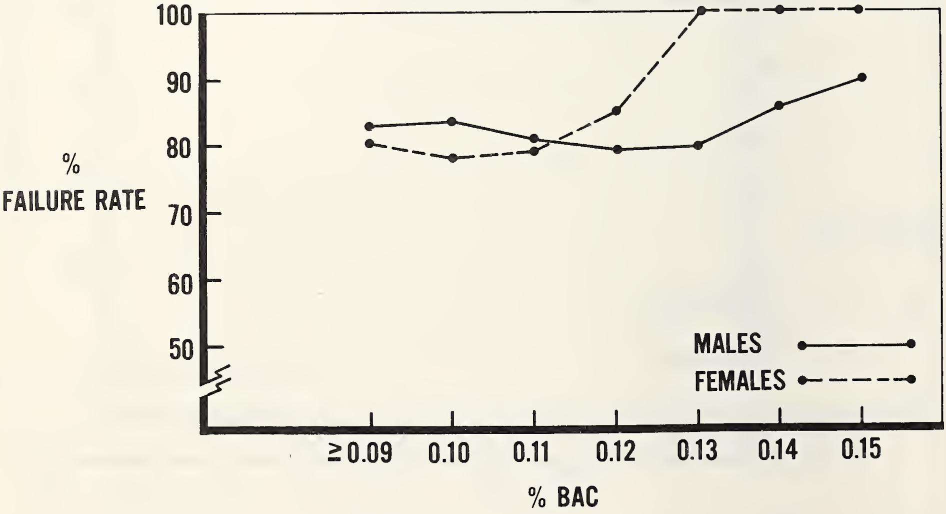


Figure 6 *Individual Threshold Failure Rates for the Male and Female Groups.*

Performance differences and educational levels. Figure 7 shows the sober and intoxicated failure rates for College Graduates and High School Graduates using the Universal Threshold criterion. Lower failure rates under the various levels of BAC for the College Graduate group can be attributed to the fact that the average level of skill acquired on the task was greater than that of the High School group. The average score on the five pre-drink trials for the College Graduate group was $\lambda = 4.8$ while for the High School Graduate group the average pre-drink score was $\lambda = 4.3$.

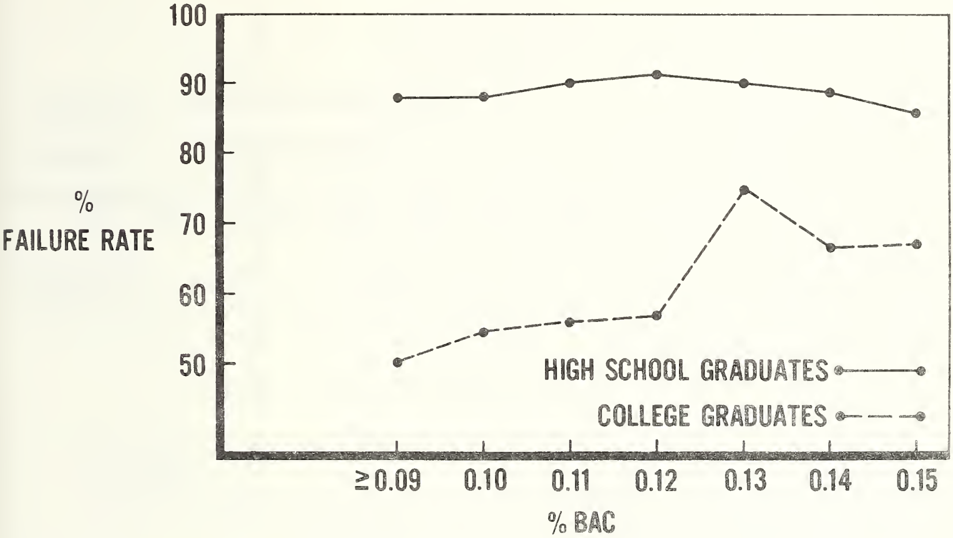


Figure 7 *Universal Threshold Failure Rates of High School Graduates and College Graduates.*

Failure rates of the two groups using the Individual Threshold criterion are presented in Figure 8. As shown, the overall failure rates are more similar due to the fact that the Individual Threshold criterion takes into account differences in levels of skill acquired on the task.

BAC group performance differences. Figure 9 presents the mean decrement in performance between the five pre-drink and five post-drink scores as related to the BAC level reached by the subjects in the test session.

As shown, all BAC groups deteriorated in performance with the decrement ranging from 0.70 for the group whose BAC was 0.10% to 1.5 for the 0.15% BAC. In addition, no subject's average performance on the five post-drink trials was greater than his pre-drink average score.

Effect of drinking habits. In order to expedite the collection of data on as many subjects as possible, the experimental design did not allow for comparisons between subjects with different drinking habits at similar BAC levels. Studies performed for General Motors by Systems Technology, Inc., with a laboratory unit do provide limited information on this effect, however.

There was significant difference between the scores obtained by the "moderate" versus "heavy" drinkers in each BAC interval, with the moderate drinkers performing

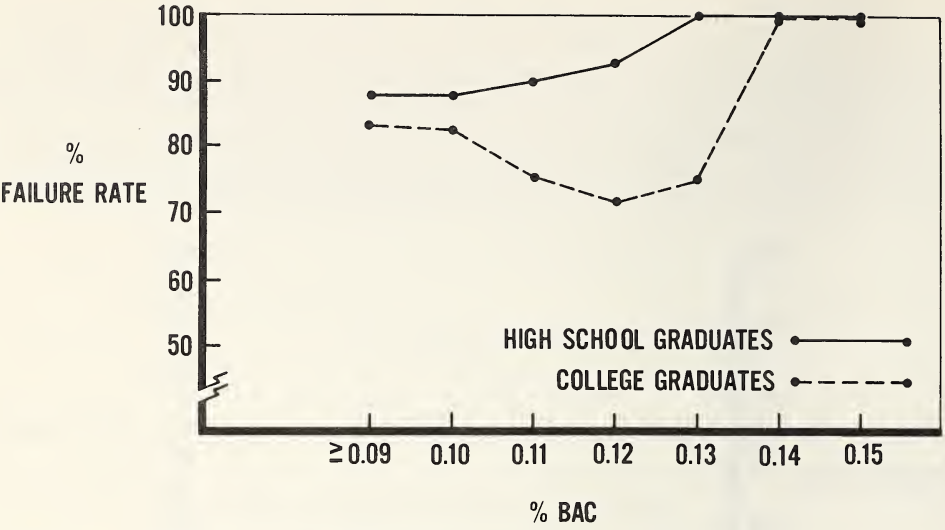


Figure 8 *Individual Threshold Failure Rates of High School Graduates and College Graduates.*

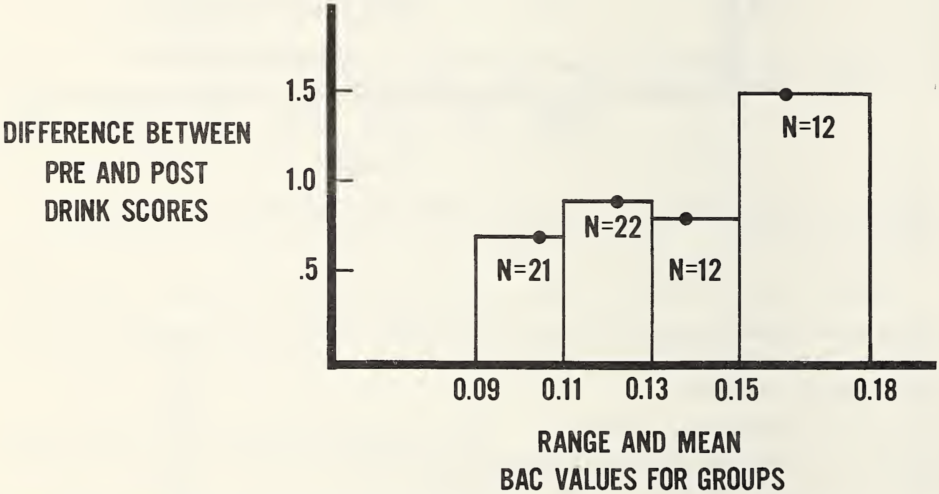


Figure 9 *Mean Difference Between Pre- and Post-Drink Scores for the 4 BAC Groups.*

more poorly than the heavy drinkers. This result is presented in Figure 10. The number of moderate and heavy subjects in each BAC interval is not equal because not all moderate drinkers were able to exceed 0.10% BAC and less than half of the heavy drinkers exceeded 0.15% BAC.

In addition to the testing of the vehicle-borne CTT units by General Motors, a CTT simulator on loan to the Department of Transportation has undergone testing in competition with other candidate systems. Blood alcohol concentrations up to and exceeding 0.18% were used, thus requiring the selection of subjects who could be expected to attain such elevated levels. From the STI findings on the effects of drinking habits on performance, one would expect less performance decrement to occur with this group of subjects at a given BAC than the typically moderate drinking subjects tested by General Motors. This was indeed the case, for in the 0.15-0.18% range, levels of discrimination comparable to what we observed for BAC ⩾ 0.10 were obtained. While some of the other devices (Reaction Analyzer, Complex Coordinator, Divided Attention) were comparable to the CTT regarding discrimination, they could not compare on features such as short task duration, simplicity, and ease of implementation.

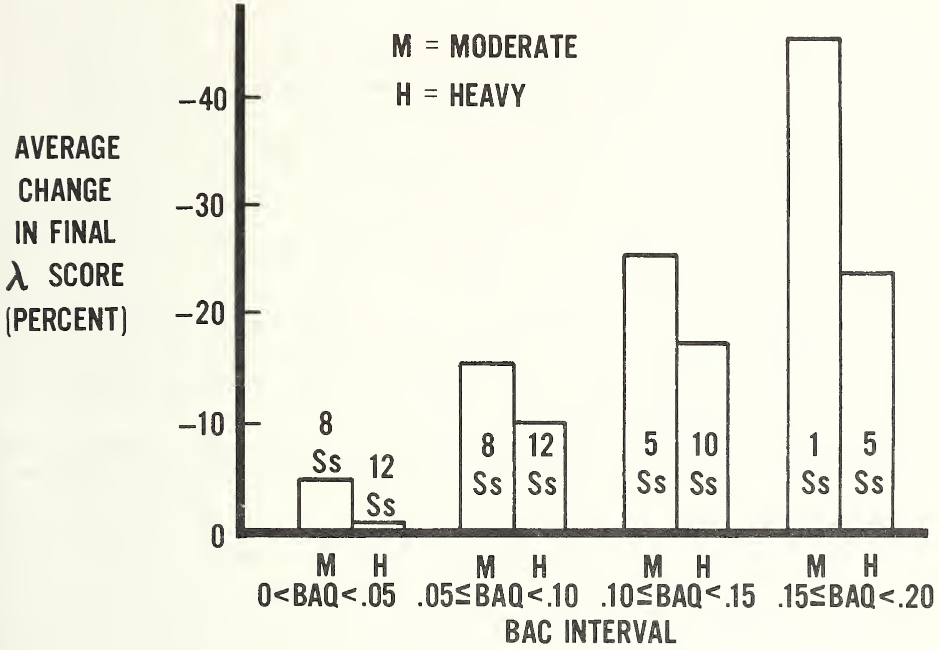


Figure 10 *Comparison of Performance Between Moderate and Heavy Drinkers Using the Laboratory System.*

DISCUSSION

As the data indicate, although the upper level at which the 0% sober failure rate is the same (λ = 4.2 for a 1 Pass out of 3 Trial criterion) in both the laboratory evaluation and the present study, greater discrimination in detecting impairment was obtained with the vehicle CTT units. This difference was probably due in part to the differences in task dynamics but more importantly to the difference in training procedures.

In the laboratory, evaluation training was massed into a two-day period with a 50 trial total. In contrast, training in the present evaluation extended over an 11-day period. This distributed type of training with a large number of trials taken typically reduces variability in performance both among and within subjects, as well as raising the average level of peak performance. Theoretically, lower peak performances should be seen with the vehicle-borne unit because of the delays introduced by the steering wheel and meter mechanisms. The same Universal Threshold (λ = 4.2) resulted from both the laboratory and vehicle units, however, indicating that the training was not equivalent. It is highly probable that had this same training procedure been used in the laboratory evaluation, the level of effectiveness at the various BACs would have been higher.

The slightly greater overall effectiveness shown by using the Individual Threshold criterion was due primarily to the change in failure rates of the College Graduate group. No other groups showed such a large difference in failure rates between the Universal and Individual Threshold analyses. This would indicate that the average performance level of the other groups was probably around the $\lambda = 4.2$ value.

Somewhat surprising was the difference between the under 30 year and over 30 year age groups. If anything, it was expected that, in general, the older subjects with more experience with alcohol, would have learned to compensate for its effects more than the younger group. As indicated above, the subjects were instructed to continue the task each time until control was lost. Because the task is a challenging one, this procedure permitted well-motivated subjects to attempt to maintain control at progressively higher levels of difficulty. As a result, they became quite skilled on the task. Although their performance deteriorated following drinking, it did not decline to the levels of less skilled subjects. One would expect that if exposure to high levels of task difficulty had been prevented by automatically terminating the task when the level of difficulty reached a set value, performance differences among subjects would have been less variable and the overall failure rates using a Universal Threshold would have been higher. Since it is likely that, if implemented, the task would be limited rather than open-ended, the effects of using this procedure during training should be evaluated. If it is successful, significantly higher failure rates in the intoxicated states using a Universal Threshold may result.

Another issue which has not been addressed in the evaluations to date is the rate of failures which may occur at BACs lower than those which legally define impairment or intoxication. While the threshold value at which no sober failures occur is an important consideration, if a significant percentage of failures begin to occur at BACs which are relatively low, the Universal Threshold value may have to be lowered. This, in turn, would reduce the overall effectiveness of using a Universal Threshold criterion.

The performance criterion presently used to determine whether impairment exists depends on whether or not the operator can maintain control up to a required level of task difficulty. In the present configuration, the time required for each trial is relatively short and more than one opportunity is allowed to meet the criterion. A disadvantage of this approach is that it is possible for the operator in an impaired state to "gather himself together" for a single trial and maintain control to the required level.

Test criteria which are based on performance on more than one trial might also be considered. In the present study, the analysis of difference scores between the pre- and post-drink performance showed a deterioration in performance with every subject. While this type of criterion would incur a larger test time penalty, a greater effectiveness in discrimination may be gained. If ignition interlocks are directed at convicted offenders, then the added time required may not be an important consideration.

At the present time, no further testing with the CTT is planned by General Motors since it is felt that significant improvements in its present performance can only be attained at a sacrifice in other desirable characteristics, such as short task duration and ease of implementation. Units are on loan to other organizations, however, where they will be undergoing further evaluation. New approaches that show potential for even greater effectiveness will continue to be evaluated in the future.

REFERENCES

1. Allsop, R. E., *Alcohol and Road Accidents. A Discussion of the Grand Rapids Study*, Road

Research Laboratory, Ministry of Transport, RRL Report No. 6, Harmondsworth Road Research Laboratory, 1966.

2. Albers, J. W., Repa, B. S., Domino, E. F., Potvin, A. R. and Tourtellotte, W. W., Effects of d-Amphetamine on Quantitative Measures of Motor Performance, *Eighth Annual NASA-Univ. Conference on Manual Control,* University of Michigan, Ann Arbor, Michigan, May 1972.
3. Alcohol and the Impaired Driver. *A Manual on the Medicolegal Aspects of Chemical Tests for Intoxication.* American Medical Association, 1968.
4. Alcohol Safety Countermeasures Program, Nat. High. Safety Bureau, June 8, 1970.
5. Allen, R. W. and Jex, H. R., Visual-Motor Response of Crewmen During a Simulated 90-Day Space Mission as Measured by the Critical Task Battery, *Seventh Annual NASA-Univ. Conference on Manual Control*, USC, Los Angeles, California, June, 1971.
6. Chernikoff, H. P. and Birminghan, R., *The Concept of Equilization Ability in Operator Selection and Training*, Birmingham, IRE-WEMA Paper 39-1, 1961.
7. *Evaluation of Phystester Ignition Interlock Device*, Systems Technology, Inc., Tech. Report No. 2021-1, June, 1972.
8. Gibbs, C. B., The Effect of Minor Alcohol Stress on Decision Processes in a Step-Tracking Task, *IEEE Transactions on Human Factors in Electronics,* Vol. HFE-7, No. 4, December, 1966.
9. *Initial Report on the Effectiveness of Physiological Readiness-to-Drive Devices*, Medical College of Wisconsin, Department of Environmental Medicine, 1971.
10. Jex, H. R., McDonnell, J. D. and Phatak, A. V., A Critical Tracking Task for Man/Machine Research Related to the Operator's Effective Delay Time, *7th IEEE Symposium on Human Factors in Electronics,* May 5, 6, 1966.
11. Jones, T. O. and Tennant, J. A., *A Critical Evaluation of the Phystester: A Test for Driver Impairment*, American Association for Automotive Medicine, Chapel Hill, North Carolina, October 20, 1972.
12. Jones T. O. and Tennant, J. A., *Alcohol Impairment Detection by the Phystester – Evaluation Program Summary SAE 730093,* January, 1973.
13. Kelley, C. R., Self-Adjusting Vehicle Simulators, paper presented at the International Congress on Human Factors in Electronics, Long Beach, California, May 3-4, 1962.
14. Klein, R. H. and DiMarco, R. J., *Sober and Intoxicated Performance on Twenty Subjects Using Modified Phystester with Individualized Response Times,* Systems Technology, Inc., Technical Report No. 2021-2, March, 1973.
15. Klein, R. H. and DiMarco, R. J., *Sober and Drunk Performance of Twenty Subjects Using First-Order and 1-1/2 Order Critical Tracking Tasks*, Systems Technology, Inc., T.R. No. 2021-3, March, 1973.
16. Repa, B. S., Albers, J. W., Potvin, A. R. and Tourtellotte, W. W., The Use of a Battery of Tracking Tasks in the Quantitative Evaluation of Neurological Function, *Seventh Annual NASA-University Conference on Manual Control*, USC, Los Angeles, California, June, 1971.
17. Smith, G. L. and McDowell, E. D., *An Investigation of Some Feasible Basics for the Design of an Automobile Alcohol Interlock System*, Ohio State University, College of Engineering, December, 1971.
18. Sugarman, R. C. and Cozad, C. P., *Experimental Results for the Optimization and Evaluation of the Phystester Ignition Interlock Device,* Cornell Aeronautical Laboratory, Inc., CAL FE-5030-B-2, May 1972.
19. Swisher, G. M. and Maher, F. A., The Degradation of Tracking Performance as a Function of Environmental Stresses of Heat and Noise, *Eighth Annual NASA-University Conference on Manual Control*, University of Michigan, Ann Arbor, Michigan, May, 1972.
20. Tennant, J. A. and Thompson, R. R., *A Critical Tracking Task as an Alcohol Interlock System,* SAE 730095, January, 1973.
21. Young, L. R. and Meiry, J. L., Manual Control of an Unstable System with Visual and Motion Cues, *IEEE Intern. Conven. Record,* Vol. 13, 1965, pp. 123-127.

Difference in Blood Alcohol Levels Following Consumption of Whisky and Beer in Man

P. Dussault[1] and C. I. Chappel

The formulation of many pharmaceutical preparations may influence the absorption of their medicinally active principles and thus their blood profiles, or as it has become known, their biological availability. It is also apparent from a number of studies, that the blood alcohol profile, after consumption of alcoholic beverages, may be affected by the form in which the alcohol is consumed. Alcoholic beverages, beer, wine and spirits contain a wide variety of chemical components peculiar to each beverage and the alcohol content varies not only between the beverages but also within the same type of beverage. Such factors and total alcohol dosage may account for the different blood alcohol curves which have been reported.

The first studies which demonstrated a difference in physiological response between alcoholic beverages were those of Mellanby (3). Using the dog as a test animal, he found a higher blood alcohol concentration (BAC) when alcohol was given in the form of whisky as compared to stout, even though both were diluted to the same concentration of alcohol. During the intervening years many studies have been reported comparing, in man, the blood alcohol curves after ingestion of whisky, brandy, beer or wine. In most instances the concentration of alcohol in the blood produced by spirits was higher than that from other alcoholic beverages. The authors of previous Canadian studies, Gardiner and Stewart (2), concluded that there were only slight and nonsignificant differences between the spirits and beer with respect to BACs.

Blood alcohol levels and differences among alcoholic beverages, in this respect, are only one aspect of the picture. The other, of pre-eminent importance, is impairment. It is well known that, for most functions, a consistent relationship exists between BAC and the degree of behavioural or functional impairment present. However, comparative studies of alcoholic beverages in this respect are few. Newman and Abramson (4) found the same degree of incoordination at a slightly higher BAC after the ingestion of dessert wine, than after distilled liquors, while Bjerver and Goldberg (1) observed that driving ability was less impaired after consuming beer than after the consumption of equal amounts of alcohol as distilled spirits. Similar results were obtained by Takala *et al* (5) who found a greater degree of impairment following consumption of brandy than after the same dose of alcohol in the form of beer, even though drink-rates were adjusted to produce the same blood alcohol levels.

---

[1] 360 Eddystone Ave., Downsview, Ontario, Canada M3N 1H7.

In view of the paucity of data from this country, we have undertaken a series of studies to clarify the picture for Canadian beverages and to define the effect of alcohol beverage dose on blood alcohol response[2].

METHOD

The beverages that were chosen were a popular Canadian rye whisky and two well known Canadian beers. The whisky was served, either neat or diluted 1:3 with water, soda water or most often ginger ale, while beers were served as taken from the bottle. The alcohol content of the whisky was 40% by volume and approximately 13.3% after dilution. The alcohol content of the beers was in one case 4.7 and in the other 5.0% by volume. These beverages were given in doses of 0.25, 0.5, 0.75, 1.0 and in the case of whisky, 1.5 grams of alcohol per kilogram of body weight (g/kg). Most studies were conducted at a dose of 0.75 g/kg of alcohol and this alcohol dose is equivalent to approximately four drinks of spirits or four 12 oz. bottles of beer for a 70kg man. Beverages were consumed during drinking sessions of 15 to 145 minutes. At a dose of 0.75 g/kg the beverages were consumed in 25 minutes.

The subject pool consisted of 26 males, 22 to 50 years of age with an average age of 32 years. Body weights were 64 to 114 kg with an average of 80 kg. Twelve of the subjects were laboratory workers, 14 were members of the local police force. On the basis of answers to a questionnaire, they might be considered as light to moderate in their drinking habits (two to three drinks per day). The subjects were fasted overnight and then given a light breakfast and a light lunch at noon. Alcohol beverages were consumed after the breakfast or during the afternoon. Each study was done on eight subjects, four of whom were consuming either beer or whisky on a given experimental occasion. Each study consisted of two experiments at weekly intervals using a crossover pattern. BACs were determined from peripheral capillary blood samples (finger prick). Duplicate samples were immediately dispensed into vials for headspace analysis by gas chromatography. Blood samples were taken prior to alcohol consumption and at 30 to 60 minute intervals for six to ten hours thereafter.

Central nervous impairment as indicated by changes of standing steadiness was measured using the statometer developed by Goldberg. Body sway in the Romberg position was converted to electrical impulses and recorded for later analysis on magnetic tape.

RESULTS

Blood Alcohol

Figure 1 illustrates the BACs after consumption of 0.75 grams/kg of whisky diluted with ginger ale and the same dose of alcohol in the form of the two beers. After consumption of whisky, the peak BAC or C_{max}, was higher than after the consumption of the same amount of alcohol in either of the two beers. The time required to

---

[2] We would like to gratefully acknowledge the advice and assistance of Dr. Leonard Goldberg of the Department of Alcohol Research at the Karolinska Institute, Stockholm; Dr. Guy Joron, physician-in-chief, St. Mary's Hospital, Montreal and the late Dr. J. Parker, professor of Pharmacology, University of Western Ontario.

reach these peak values, which is termed that t_{max}, was also shorter after consumption of whisky than after consumption of either beer. The descending portions of the curves are almost identical and in these experiments the subjects reach a zero blood alcohol value at the same time irrespective of the beverage consumed. To put it in other words, the rate of elimination and the time required to completely eliminate blood alcohol were the same whether the alcohol was consumed as whisky or beer. We found no appreciable differences in the blood alcohol curves for whisky, whether the whisky was consumed neat or diluted 1:3 with water, soda water or ginger ale.

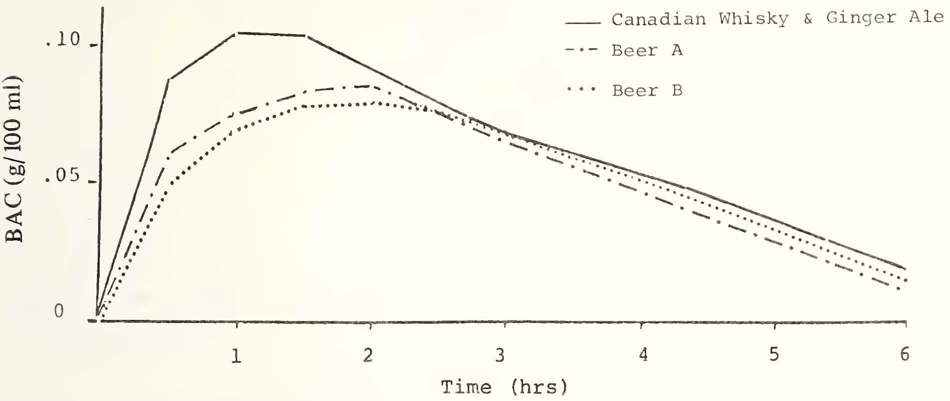


Figure 1 *Blood alcohol curves.*

The differences between the whisky and beer blood alcohol curves in terms of C_{max} and t_{max} values were present when whisky and the beers were compared over a wide dose range. These studies are summarized in Figure 2. In this Figure we have plotted the C_{max} values on the ordinate and the t_{max} values on the abscissa for dose levels of the 0.25, 0.5, 0.75, 1.0 and 1.5 g/kg of alcohol in the form of whisky or beer. The coordinates representing each beverage at a given dose have been joined. It should be noted that the figure for the 1.5 g/kg dose of alcohol as beer, has been extrapolated from the remaining data as our subjects were unable to consume this volume of alcohol as beer in the required drinking time. At the 0.25 g/kg dose level there were no significant differences between the coordinates for beer or whisky. At all higher dose levels the differences were statistically significant and the magnitude of these differences increased with increasing doses of alcohol.

STATOMETRY

In order to determine whether different beverages at similar BACs reflected different degrees of impairment, psychomotor testing was carried out using a Statometer. With this device body sway and coordination were measured before and after the ingestion of 0.75 g/kg of alcohol in the form of whisky or the two beers.

Under normal circumstances, when the body is in the erect position and standing still, there is a significant body sway that is made up of forward and backward — sagittal — as well as side to side — lateral — components. Under the influence of alcohol, body sway dramatically increases in both frequency and amplitude.

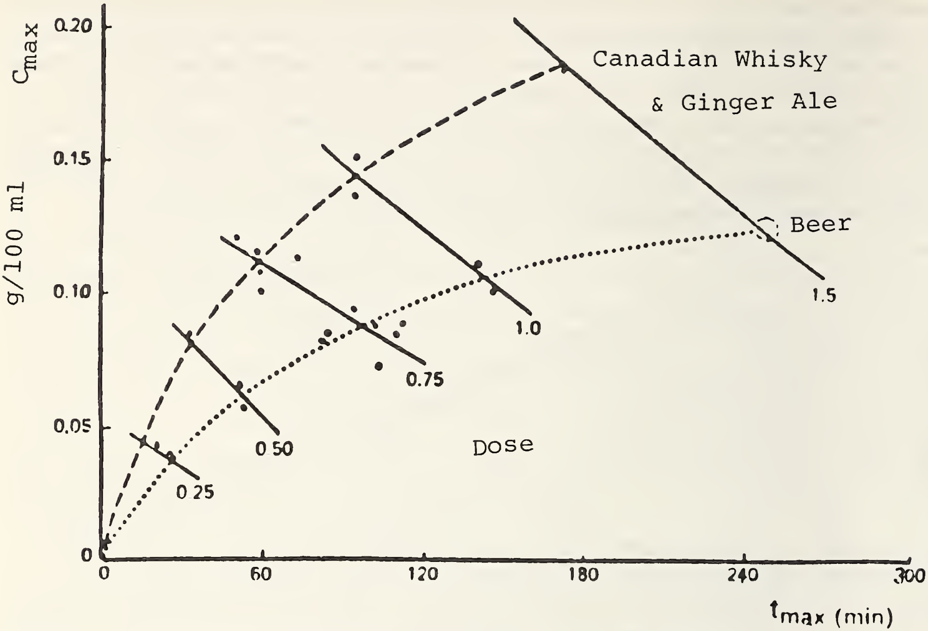


Figure 2 *Relationship between dose of alcohol and C_{max}, t_{max} Values.*

Before, and at hourly intervals after, ingestion of the beverages, subjects were required to stand on the Statometer platform with feet together and hands by the body (Romberg position) for 70 seconds with the eyes open and then 70 seconds with the eyes closed. Appropriate transducers, mounted in the platform, detected the direction and intensity of body sway in both directions, and transformed the mechanical movements of the body into electrical signals. These analog signals were recorded and stored on magnetic tape and monitored on a Grass Polygraph. For evaluation, the stored analog signals were converted in an A/D converter into impulses, counted during one second periods and printed out. Mean amplitudes and variability of sway were then statistically analyzed.

In this study, the post-treatment data were compared to those of the pre-treatment period and expressed as percent change against time. It may be seen from Figure 3 which illustrates the course of the changes in amplitude for sagittal sway with eyes closed and open, that body movements in general reflect body alcohol concentrations. An increase in body sway occurs as BAC builds up and this reverts to normal, coincident with elimination of blood alcohol. The extent of these changes was found to be greater with whisky than with beer, particularly with the eyes closed and this was the case for either sagittal or, as illustrated in Figure 4, lateral sway. The same profile for change in body sway was observed when whisky, again at 0.75 g/kg dose level of alcohol, was compared with a second beer.

DISCUSSION

The results of our studies with Canadian beers and a Canadian whisky confirm the differences in BAC reported for different alcoholic beverages by others. As exemplified by our studies at a dose of 0.75 g/kg of alcohol in the form of whisky or beer,

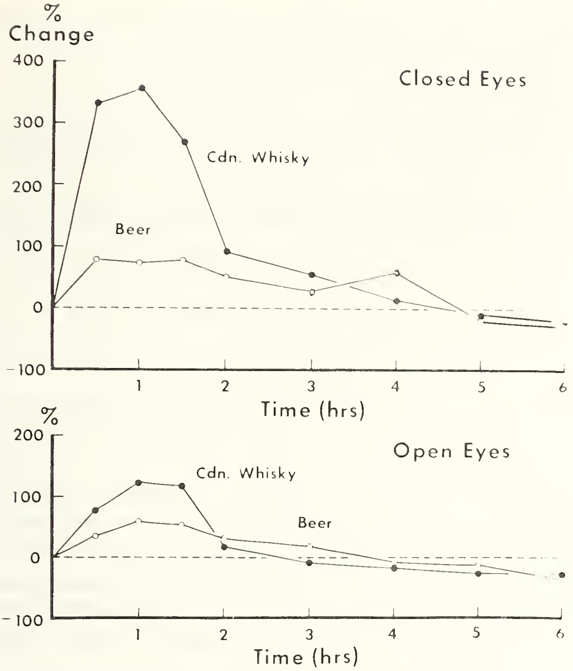


Figure 3 *Standing steadiness: Lateral sway.*

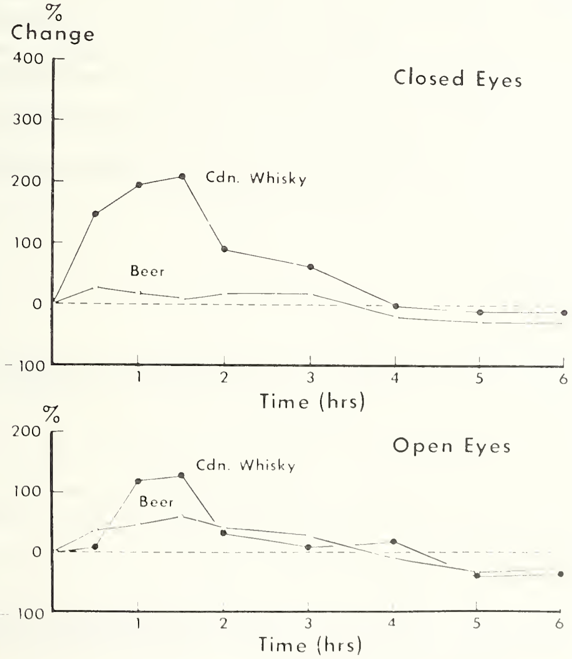


Figure 4 *Standing steadiness: Sagittal sway.*

consumed over a period of 25 minutes, BAC is greater following ingestion of whisky and impairment greater as measured by the Statometer, than after the consumption of the same amount of alcohol as beer. The studies which we have done at different levels of beverage consumption demonstrate the importance of alcohol dosage in determining whether or not such differences are observed. In this respect not only alcohol dosage but also drinking times are crucial and, as has been shown by many others, differences may not be present when the beverages are consumed in the "fed" as contrasted with the "fasting" state. Differential absorption rates of the alcohol from the different alcoholic beverages have been considered as an explanation and various factors may influence this rate of uptake. These include alcohol concentration and volume in which the given dose of alcohol is consumed, as well as extract content or buffer capacity of the beverage, but as yet one cannot draw firm conclusions as to the mechanism involved.

The social implications of these findings are not as straightforward as they might appear. It is apparent that under certain circumstances the consumption of alcohol in the form of one alcoholic beverage may produce higher BACs and a greater degree of impairment than when the same dose of alcohol is consumed in a different alcoholic beverage. Our findings with respect to the C_{max} for these alcoholic beverages consumed during a relatively short time period demonstrate that there is a dose threshold above which differences in the BAC are present. In this study, when the beverages were consumed over a 25-minute period this threshold appeared to be lower than 0.5 g/kg. At 0.75 g/kg also consumed in 25 minutes, the differences in the C_{max} between beverages were clearly present.

On the other hand, on the basis of preliminary results from recent studies, it appears that when the drinking period is extended it is necessary to raise the dose of alcohol to obtain similar differences. This suggests that there is a moving threshold at which BAC differences related to beverage appear and that this threshold is dose and drinking duration dependent. In the near future we hope to have a complete definition of this threshold for alcoholic beverage differences and similarities over a range of dosage and drinking durations. The relevance of beverage differences for any social drinking pattern could then be judged against this model. Until such a model is available, in our opinion, one should use caution in generalizing with respect to alcoholic beverage differences or lack thereof from studies of any one dosage or drinking duration.

REFERENCES

1. Bjerver, K. and Goldberg, L. Effect of Alcohol Ingestion on Driving Ability. Results of Practical Road Tests and Laboratory Experiments. *Quarterly Journal of Studies on Alcohol* 11, 1-30, (1950).
2. Gardiner, R. J., Stewart, H. B., Blood Alcohol and Glucose Changes after Ingestion of Ale, Wine and Spirits. Quarterly Journal of Studies on Alcohol. Part A 29, 313-322, (1968).
3. Mellanby, E., *Alcohol: Its Absorption into and Disappearance from the Blood under Different Conditions.* Medical Research Committee publication. Special Report Series No. 31 London. His Majesty's Stationery Office, 1919, p. 48.
4. Newman, H. W. and Abramson, M. Absorption of Various Alcoholic Beverages. *Science* 96, 43, (1942).
5. Takala, M., Pihkanen, A., Markkanen, T. *The Effects of Distilled and Brewed Beverages.* Publication No. 4 of The Finnish Foundation for Alcohol Studies. Printed by Suomalaisen Kirjallisundes Kerjapaino Oy Helsinki, 1957.

Sensorimotor and Physiological Effects of Various Alcoholic Beverages

H. Kalant[1], A. E. LeBlanc, A. Wilson and S. Homatidis

The question of differences in intoxicating potency of various alcoholic beverages has been the subject of many scientific investigations. One of the main questions has been whether beer and wine are less intoxicating than distilled spirits, in doses which provide an equal amount of absolute alcohol. Several investigators (5, 9, 11-14) have reported a more rapid and higher rise in blood alcohol following the ingestion of distilled spirits than after the same amount of alcohol in the form of beer. Various measures of intoxication have also shown greater impairment after ingestion of distilled spirits than of the other beverages, consistent with the differences obtained in blood alcohol levels. Dussault *et al* (2) verified these results with Canadian beverages and Canadian subjects. This comparison is of special interest, in view of the finding that Canadian rye whiskey and Scotch whiskey differ substantially from bourbon with respect to the types and amounts of congeners they contain (6).

If these differences are indeed valid under ordinary conditions of use, and if differential price, by taxes or other means, can modify the patterns of consumption of different beverages in a population (1) such information could form the basis of social policy for minimizing the undesired consequences of intoxication, such as motor vehicle accidents. However, most of the experimental studies in the literature have employed schedules of alcohol consumption that bear little resemblance to the manner in which alcohol is generally consumed. For example, in the study by Dussault *et al* (2), the subjects were required to drink amounts of alcohol equivalent to eight ounces of Canadian spirits in a 25-minute period, following a 12-hour fast. The purpose of the present study, therefore, was to repeat the comparison of Canadian beverages with a rate of consumption and drinking conditions more closely comparable to those characteristic of most social (*i.e.*, non-experimental) use of alcohol.

METHODS

Subjects

The experiments were carried out on 16 healthy male volunteers with an age range of 20-30 years (mean 25.0 years) and a weight range of 116-198 lbs. (mean weight 163.7 lbs. = 74.4 kg). Despite the range of body weights, all subjects were of essentially

---

[1] Addiction Research Foundation, 33 Russell St., Toronto, Ontario, M5S 2S1, Canada.

normal weight for their respective heights. All were moderate drinkers, who used alcohol, on the average, twice weekly with about 3 drinks on each occasion. More than half of them listed beer and less than a quarter listed spirits as their usual drink. Subjects were asked to refrain from taking any drugs or alcohol for 24 hours before the experimental sessions. For verification a routine drug-screening analysis was carried out on urine samples and the zero time blood sample, taken on each test day.

Procedure

One week prior to the first experimental session, each subject was given a thorough medical examination, followed by ten 1-minute practice trials on the pursuit rotor test (see below). At the beginning of each experimental session, subjects received a standard light lunch; no other food or beverage was provided before the test. Following this, the subjects went through the experimental procedure in pairs, in a living-room-like setting, with a minimum of direct disturbance by the experimenters. Since there was only one apparatus available for each type of test procedure, the starting times were staggered by 30 minutes so that each subject would be tested at the same elapsed time after the end of each drinking period. After the end of each experimental session, the subjects were escorted to the Clinical Institute of the Addiction Research Foundation, where they remained under medical supervision until the blood alcohol level had fallen to less than 30 mg/100 ml.

The basic experimental design was a 4 x 4 Latin Square, in which each of four subjects was tested under the effects of placebo and three different alcoholic beverages as described below, on occasions at least one week apart. Because of these intervals between tests with the same subject, two replications of the Latin Square (8 subjects) were run as one block, and then the whole block was repeated with 8 different subjects. To minimize systematic order effect, each of the four Latin Squares was different from the others.

Beverages and Drinking Schedule

The alcoholic beverages employed were a Canadian rye whiskey, 40% alcohol by volume, mixed 1:1 with ginger ale; a Canadian lager beer, 5% alcohol by volume; and a sparkling rosé table wine, 11.26% alcohol by volume. The control beverage was a carbonated caffeine-free soft drink, served in a volume mid-way between the respective volumes of beer and the rye and ginger ale mixture. All beverages were served chilled, and the doses were adjusted according to the body weight of the subject on each experimental day.

The schedule of beverage consumption is indicated in Table I. This schedule was based on information derived from two sources. The first was the published work of Takala *et al* (13), in which a program of alcohol administration was set up on the basis of the observed rates at which subjects drank under *ad libitum* conditions. The second was the unpublished observations by R. E. Popham on the patterns of consumption by tavern patrons, including a group who would be considered alcoholics by conventional clinical criteria. The experimental schedule shown in Table II notes that the total session consisted of a 30-minute period for baseline measures, followed by four 75-minute blocks, each consisting of a 45-minute drinking period followed by a 30-minute test period. The total beverage ration for each drinking period was given to the subject at the start of the block, and he was permitted to consume it at his own rate during the 45-minute drinking time.

TABLE I *Drinking Schedule*[a]

Time	Absolute Alc. (ml) per 70 kg.	Beer 5% vol ml.	Rye 40% vol ml.	Wine 11.26% vol ml.
30-75 min. 0.62 ml/kg	43.5	870	108.75	386.28
105-150 min. 0.35 ml/kg	24.5	490	61.25	217.56
180-225 min. 0.32 ml/kg	22.5	450	56.25	199.8
255-300 min. 0.30 ml/kg	21.0	420	52.5	186.5

[a] The doses used by Takala *et al* (13) were lowered by 25% to give blood levels of 100 to 120 mg/100 ml instead of original 150 mg/100 ml. The total dose of ethanol in the experiment was 1.3 g/kg.

TABLE II *Experimental Timetable*[a]

Arrival – Weight, Urine Sample, 5 Trial Practice on Pursuit Rotor, Lunch.

0-30 min. Baseline measures	Pursuit Rotor – 5 Trials Romberg Skin Temperature Heart Rate and Flush Blood Sample
30-75 min.	Drink I
75-105 min.	Testing (as above)
105-150 min.	Drink II
150-180 min.	Testing
180-225 min.	Drink III
225-255 min.	Testing
255-300 min.	Drink IV
300-330 min.	Testing
330 min.	End of experimental session – breathalyzer reading taken and *S*'s escorted to clinic for recovery

[a] Each *S* was run according to this schedule on each experimental day.

TEST PROCEDURES

Sensorimotor Tasks

The Photo Electric Rotary Pursuit apparatus (Lafayette Instrument Co., Model 2203 ET) was used as a measure of eye-hand coordination. Subjects were required to follow a moving light (30 rpm) in a square pattern with a photo-sensitive wand. Cumulative time on target was measured for each trial. To control for the learning effect, subjects were given ten 1-minute practice trials during the preliminary session and an additional set of five 1-minute trials prior to the baseline period of each experimental session. Each testing period throughout the experimental sessions involved five 1-minute trials with a 30-second rest between trials.

The Romberg test was quantified by means of an apparatus which provided continuous records of front-to-back and lateral body sway (3, 4). Subjects were tested in three positions: feet together, eyes open; feet together, eyes closed; and feet in line, eyes open. The frequency and maximum amplitude were recorded for each direction of sway during one minute in each of the positions. For analysis, the total amplitude score and the total frequency score for all three positions was obtained at each test time.

Physiological Tests

Immediately after completion of the sensorimotor tasks, the skin temperature, heart rate and degree of malar flush were measured. Skin temperature was measured by means of a Yellow-Springs Electronic Thermometer (model No. 44TA) with a banjo thermister probe held to the subject's cheek. Heart rate and degree of flush were recorded on a Texas Instruments Physiograph, using a photosensitive (red reflectance) transducer held to the cheek.

Blood Alcohol Measurements

Samples of finger-tip capillary blood were obtained with a disposable microlance and 50 μl capillary pipettes at the end of each test block. The samples were immediately laked and deproteinized for analysis of ethanol concentration by gas-liquid chromatography with n-butanol as internal standard (8).

RESULTS

Blood Alcohol Curves

Since the experiment was carried out with two successive blocks of eight subjects, the blood alcohol curves for the two blocks were plotted separately before the results were pooled. The blood alcohol curves (Figure 1) indicated a difference between the two groups, which proved to be significant on analysis of variance ($F = 35.5$; $df = 1, 14$; $p < 0.01$). However, there was no significant difference between the blood alcohol curves for the various beverages across all 16 subjects, and no interaction between beverages and the two subject groups. For this reason, and since each subject served as his own control with all beverages, it was permissible to pool the various test results for all subjects for a composite Latin Square analysis. This revealed no significant consistent order effect, but there was a highly significant effect of beverages which was entirely attributable to the difference in results between the placebo and the three alcoholic beverages (see Figure 2). The subsequent analysis was therefore confined to an analysis of variance of the results with the three alcoholic beverages.

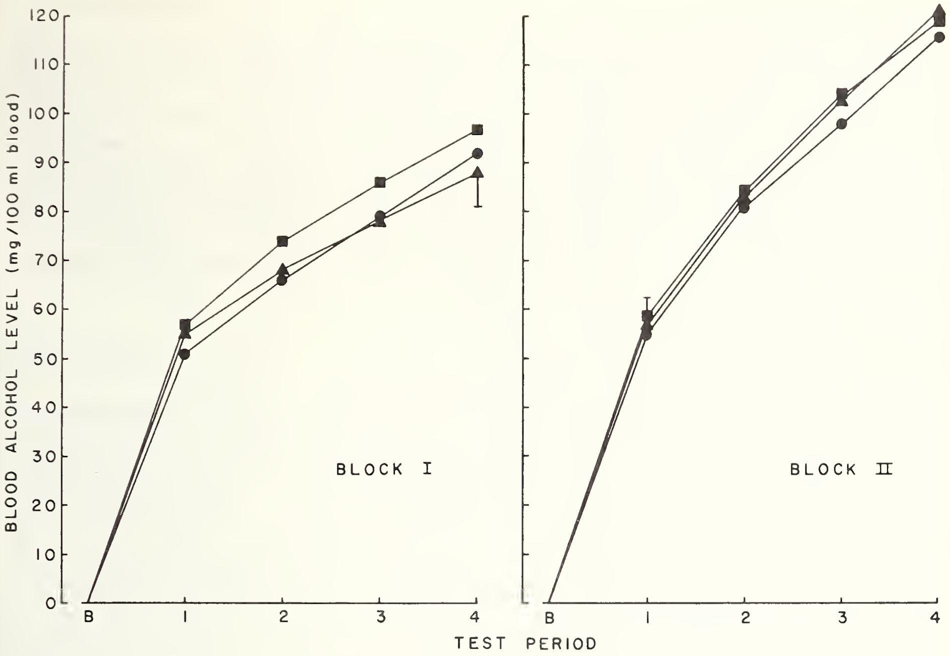


Figure 1 *Blood Alcohol Curves in mg per 100 ml. for Blocks I and II. The points represent the mean of eight values each, for eight subjects receiving the same dose of alcohol as rye* ▲——▲, *wine* ■——■, *and beer* ●——●. *The largest single standard error of any point is represented by the vertical bar in each graph.*

TABLE III *Summary of Statistical Analyses for Factors Other Than Alcoholic Beverage*

VARIABLE	ANALYSIS		
	Analysis of variance, baseline scores on four test days	Analysis of variance, effect of control beverage	Latin square analysis, effect of session
Heart rate	N.S.[a]	$p < 0.01$	N.S.
Flush	N.S.	N.S.	Test 2[b], $p < 0.05$
Skin temperature	N.S.	$p < 0.01$	N.S.
Pursuit rotor	N.S.	N.S.	N.S.
Romberg frequency	N.S.	N.S.	Tests 1 & 4, $p < 0.05$
Romberg amplitude	N.S.	N.S.	N.S.

[a] N.S. indicates $p < 0.05$.

[b] Test numbers refer to the test periods during the drinking period of each experimental session.

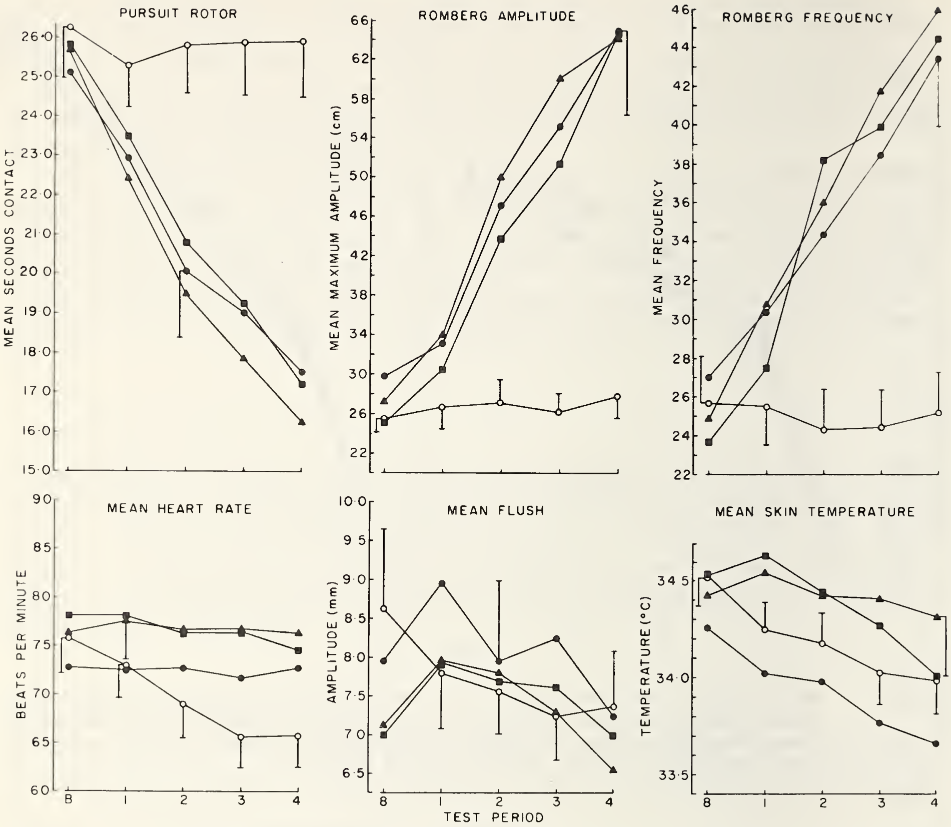


Figure 2 *Results for the 16 subjects on the tests as labelled at various times after drinking rye ▲——▲, wine ■——■, beer ●——●, and the control beverage ○——○. The largest single standard error is shown for the alcoholic beverages and the standard error is shown at each point for the control beverage.*

TABLE IV *Analysis of Variance for Changes in Test Scores During Alcohol Drinking Sessions*

Variable	Effect of beverage[a]	Effect of cumulative dose[b]	Interaction beverage x dose
Blood alcohol level	N.S.[c]	$p<0.01$	N.S.
Heart rate	N.S.	N.S.	N.S.
Malar flush	N.S.	$p<0.01$	N.S.
Skin temperature	N.S.	$p<0.01$	N.S.
Pursuit rotor	N.S.	$p<0.01$	N.S.
Romberg frequency	N.S.	$p<0.01$	N.S.
Romberg amplitude	N.S.	$p<0.01$	N.S.

[a] This refers to effect of whisky *vs.* wine *vs.* beer.

[b] Refers to change of scores over successive test periods within the same session, in response to continued drinking.

[c] N.S. indicates $p<0.05$.

Test Results

Analysis of variance (Table III) indicated that there was no significant difference with respect to any of the variables measured, during the pre-drink baseline measurements on the same subjects on different test days. With the exception of heart rate, all of the tests showed a clear change over time (Figure 2) which in effect corresponded to a progressive change in blood alcohol level. The significance of changes in test scores, as revealed by the analysis of variance, is summarized in Table IV. Despite the evidence of a marked alcohol effect on five of the six tests, there was no significant difference among the three alcoholic beverages on any of them.

DISCUSSION

The difference in blood alcohol curves between the two groups of eight subjects was not anticipated. When it was found, an examination of the drinking histories revealed that group 2 regularly consumed more alcohol than group 1. The steeper blood alcohol curves for the group 2 subjects are therefore entirely consistent with the observation by Newman (10, p. 9) that heavier drinkers tend to absorb the alcohol more rapidly. This appears to be true independently of which beverage is involved.

This would have introduced a serious problem for interpretation of studies based on group comparisons, in which different groups of subjects received different beverages. In contrast, it is of no importance in a Latin Square design, in which each subject receives all treatments and serves as his own control. For this reason, the Latin Square design maximizes the chances of showing a difference between beverages if there is one, and therefore the present results reinforce the importance of the negative finding with respect to such difference.

The results in Figure 2 indicate a more clear-cut and consistent alcohol effect upon the psychomotor performance tests than on the autonomic measures. The reason for the difference is not entirely evident from the present work, but two or three possible explanations may be suggested. One is that homeostatic changes are considerably more rapid for autonomic functions, especially those affecting heart rate, than for purely central nervous system functions. Therefore, the alcohol effects may have been more rapidly corrected or more variable over time. A second factor is that the different alcoholic beverages were adjusted to provide the same dose of ethanol, but differed substantially in the total fluid volume. This factor might have introduced variability in the cardiovascular measures, tending to obscure any common effect of ethanol. On the other hand, this might have caused an apparent beverage effect, so that the absence of the latter is even more striking. A third possible explanation is that differences in emotional tension connected with the test situation would introduce greater variability in the autonomic measures than in the psychomotor performance measures. Although the test situation was a comfortable one, and the novelty was lost on repeated sessions with the same subjects, it is impossible to exclude this factor completely.

By far the most important finding of this study is the absence of any significant differences among the three alcoholic beverages, at the same dose of ethanol, with respect to either the blood alcohol curves or the observed effects. It is therefore necessary to account for the difference between these findings and those of other investigators such as Dussault *et al* (2). The explanation is probably a very simple one, resting on well established facts of alcohol physiology. The absorption of ethanol from the gastrointestinal tract proceeds by a process of simple physical diffusion (7) so that the rate of absorption is markedly dependent on the concentration gradient of ethanol between the content of the lumen and the blood perfusing the submucosal capillary network. In addition, the diffusion proceeds more rapidly through the thinner mucosa of the small intestine than through the gastric mucosa. Therefore, absorption proceeds more rapidly when gastric emptying time is shorter.

For these reasons, the ingestion of the entire amount of alcohol as a single large dose, taken on an empty stomach, would maximize the importance of the concentration gradient as a determinant of the rate of rise of blood alcohol level. This is the situation in the study by Dussault *et al* (2). In contrast, the ingestion of alcohol in divided doses spaced over time, and following food intake, would minimize the importance of the concentration gradients as in the present study. In real life, even alcoholics show a drinking pattern which is much closer to the second than to the first type. It is noteworthy that the reported difference between beverages in the study by Dussault *et al* (2) was evident only during the first half hour. After this time, the differences in concentration gradient across the intestinal mucosa would have become minimal, and with the increasing approximation of the blood levels to each other, the effects of the alcohol also became relatively independent of the beverage type.

The importance of the present findings can be expressed in both medical and social policy contexts. In a medical sense, it is worth pointing out that the undesired effects of acute intoxication, such as behavioral disturbances, motor vehicle accidents and other consequences of CNS impairment, are most unlikely to be significantly influenced by the choice of alcoholic beverage, but heavily dependent on the amount and rate of ethanol consumption. The same would hold true for undesired interactions between ethanol and other drugs which affect the CNS, such as antihistaminics, minor tranquillizers and barbiturates.

With respect to social policy the present findings suggest that any attempt to promote the use of one beverage in preference to another, by such means as differential taxation, must rest entirely on economic or political grounds because it is not defensible on medical or pharmacological grounds.

SUMMARY

Sensorimotor and physiological effects of equivalent doses of alcohol in the form of Canadian rye whiskey (diluted 1:1 with ginger ale), Canadian beer and a sparkling table wine were compared with those of a non-alcoholic carbonated control beverage. A total alcohol dose of 1.3 g/kg was consumed over four hours, beginning one hour after a standard light meal. Sixteen male subjects aged 20-35 years, all moderate drinkers, were tested in pairs in a replicated 4 x 4 Latin Square design. Pre-drinking base line measurements were made on the pursuit rotor, quantitative Romberg tests, skin temperature, heart rate, facial flush and blood alcohol level. The same measures were repeated at regular intervals over the 4-hr. drinking period.

The three alcoholic beverages produced blood alcohol curves that did not differ significantly. As compared to the control beverage, the three alcoholic beverages produced increasing impairment over time, which corresponded in degree to the rising blood alcohol levels. There were no significant differences among the three alcoholic beverages on either the sensorimotor or physiological measures at any blood alcohol level. The results of this study indicate that the degree of impairment following alcohol ingestion in a socially relevant manner is dependent, not on the type of beverage consumed, but on the resulting blood alcohol concentration.

REFERENCES

1. de Lint, J. and Schmidt, W., Consumption Averages and Alcoholism Prevalence – Brief Review of Epidemiological Investigations. *British Journal of Addiction* 66, 97 (1971).
2. Dussault, P., Burford, R. and Chappel, C., *Studies of Alcoholic Beverages. Physiological Effects.* Bio-Research Lab. (Breweries Association) Bio-Research Lab Report, 1972.
3. Edwards, A. S., Static Ataxiamiter for Head and Hips. *American Journal of Psychology* 55, 576 (1941).
4. Edwards, A. S., The Measurement of Static Ataxia. *American Journal of Psychology* 55, 171 (1942).
5. Gardiner, R. J. and Stewart, H. B., Blood Alcohol and Glucose Changes After Ingestion of Ale, Wine and Spirit. *Quarterly Journal of Studies on Alcohol* 29, 313 (1968).
6. Greenberg, L. A. (ed.), Studies of Congeners in Alcoholic Beverages. *Quarterly Journal of Studies on Alcohol,* Supplement 5, 1970.
7. Kalant, H., Absorption, Diffusion, Distribution, and Elimination of Ethanol Effects on Biological Membranes. In: *Biology of Alcoholism.* Vol. 1. B. Kissin and H. Begleiter (eds.), Plenum Press, New York, 1971, pp. 1-62.
8. LeBlanc, A. E., Microdetermination of Alcohol in Blood by Gas-Liquid Chromatography. *Canadian Journal of Physiology and Pharmacology* 46, 665 (1968).
9. Lolli, G., Nencini, R. and Misiti, R., Effects of Two Alcoholic Beverages on the Electroencephalographic and Electromyographic Tracings of Healthy Men. *Quarterly Journal of Studies on Alcohol* 25, 451 (1964).
10. Newman, H. W., *Acute Alcohol Intoxication.* Stanford University Press, Stanford, California, 1941.
11. Pihkanen, T. A., On Static Atactic Functional Disorder Caused by Alcohol. A Comparative Study of Different Beverages. *Quarterly Journal of Studies on Alcohol* 18, 183 (1957).
12. Pihkanen, T. A., *Neurological and Physiological Studies on Distilled and Brewed Beverages.* Maalaiskuntein Lüton Kiyapaino; Helsinki, 1957. Also in: *Annales Medicinae Experimentalis Biologiae Fenniae* 35, (Supplement 9), 1 (1957).
13. Takala, M., Pihkanen, T. A. and Markkanen, T., *The Effects of Distilled and Brewed Beverages.* A Physiological, Neurological and Psychological Study. The Finnish Foundation for Alcohol Studies, Helsinki, 1957.
14. Takala, M., Siro, E. and Toivainen, Y., Intellectual Functions and Dexterity During Hangover. *Quarterly Journal of Studies on Alcohol* 19, 1 (1958).

Social Patterns of Drinking in Young People and the Related Blood Alcohol Levels

J. N. Santamaria[1]

The Australian mainland is divided into six States – the smallest in size being Victoria which, however, has the second largest population. The last official Census in 1971 showed that Victoria had a population of three and a half million inhabitants of whom 1.2 million resided in the metropolis of Melbourne.

During 1973, there were 935 individuals killed on Victorian roads (6.2 per 10,000 registered vehicles) and 20,000 injured (132.7 per 10,000 registered vehicles). In all, there were 14,485 reported casualty traffic accidents.

Victoria was the first State to introduce legislation to prohibit drivers with elevated blood alcohol levels from driving motorized vehicles. Following a Royal Commission into the Sale and Supply of Liquor, the Victorian Government in February, 1966, set the legal limit of blood alcohol concentration (BAC) at 0.05 g/100 ml (%). Other States have since followed this lead, but they have legislated at 0.08%. However, a senior advisory body to the Federal Department of Health has recently recommended that all States should adopt the 0.05% limit.

It has since become obvious that most drivers equate their ability to drive a motor vehicle with their ability to perform the routine sobriety tests, or with the feeling of being intoxicated or not. On questioning a sample of convicted drinking drivers, we found that few had any realistic conception of how much alcohol they could drink in different social settings if they wanted to be within the legal limit when driving away at the end of a drinking session. Moreover, they had virtually no knowledge of the effects of alcohol on those skills and mental faculties so necessary for safe driving.

In early 1973, The Road Safety and Traffic Authority decided to conduct an extensive community programme to educate the public in safe and responsible driving. However, the Authority lacked adequate knowledge on which to base their programme.

At about this time, we at St. Vincent's Hospital, Melbourne, were anxious to introduce a Rehabilitation Course for young convicted drinking drivers, and we had decided to conduct a set of drinking experiments with young males under the age of 25, in different drinking situations. We wanted to find the answers to the following questions:

---

[1] Director, Department of Community Medicine, St. Vincent's Hospital, Melbourne, Australia.

1. How much alcohol does it take to reach 0.05, both on an empty stomach and with food?
2. How quickly is alcohol eliminated from the blood?
3. How much alcohol can a person safely drink to remain within the legal limits in common drinking situations?
4. Does the taking of food affect the BAC if the rate of drinking remains the same?
5. At what BAC does a person's judgment become affected so that he fails to appreciate that his driving ability may be impaired?
6. Are there any differences to be noted which are dependent on the nature of the beverage consumed?

METHODOLOGY

We adopted the term of a "Standard Drink" to conform to the ordinary serving of each beverage in a hotel or licensed restaurant. Standard drinks contained the following amounts of ethanol.

1. Seven ozs (210 ml) of draught beer contained 8 g.
2. Three ozs of riesling (90 ml) contained 7.4 g.
3. Two and a half ozs of claret (75 ml) contained 8 g.
4. One oz (30 ml) of whisky contained 9.2 g.
5. One oz (30 ml) of white rum contained 9.2 g.

A set of four experiments were organized, involving males between the ages of 18 and 25. The first two experiments were held at a modern drive-in hotel, and the youths who participated were volunteers from a local youth club.

TABLE I *The Four Experiments*

Experiment number	Number of sessions	Condition	Type of beverage	Quantity drunk in ml. 1st hr.	2nd hr.	3rd hr.
1	6	fasting	beer	1260	0	0
	12	fasting	beer	1260	630	630
	12	fasting	beer	1260	1260	1260
2	9	fasting	beer	1260	–	–
	9	snack	beer	1260	–	–
	12	meal	beer	1260	–	–
3	7	fasting	beer	840	420	420
	3	fasting	white rum[b]	120	60	60
	5	fasting	whisky[b]	120	60	60
4	7	three course meal in first hour	beer	840	420	–
	6		riesling[c]	360	180	–
	4		claret[d]	360	180	–

[a] One standard drink of beer = 210 ml.
[b] One standard drink of white rum or whisky = 30 ml.
[c] One standard drink of riesling = 90 ml.
[d] One standard drink of claret = 75 ml.

Experiment 1

The participants were divided into three groups and all drank beer on an empty stomach. The first group drank six glasses of beer in the first hour only; the second group drank six glasses in the first hour, three glasses in the second hour and three in the third hour. The third group drank six glasses of beer in each hour of the three-hour session.

Experiment 2

The participants were again divided into three groups and again drank only draught beer. Group 1 drank six glasses of beer on an empty stomach over one hour. Group 2 drank the same amount in the same period but the participants ate peanuts, potato chips and other snacks. The third group drank the same amount whilst eating a full meal over the one-hour period.

In each of the above two experiments there were 30 subjects and they were matched with observers who supervised the rate of drinking and the supply of food, and who recorded certain specified observations.

Experiments 3 and 4 were conducted in a club, and the subjects were volunteer students from the University of Melbourne and were drawn from several faculties including the humanities and sciences.

Experiment 3

This experiment was carried out with the subjects fasting. Again, three groups were selected but the beverages were varied and the rates of drinking altered. Each group drank four standard drinks in the first hour, two in the second and two in the third. The beverages used were draught beer, whisky and white rum.

Experiment 4

The subjects in this experiment were divided into three groups and each person ate a full smorgasbord meal during the first hour. Group 1 drank four glasses of beer during the meal and then drank another two glasses in the next hour. Group 2 drank four glasses of a white dry wine (riesling) with the meal, and then two glasses in the second hour. Group 3 also drank wine, but claret was substituted for the riesling.

In all experiments the BACs were estimated with breathalyser units, standardised and operated by members of the Breath Analysis Squad of the Victoria Police Department.

RESULTS

The data obtained from the above experiments were grouped to form the following studies:

Study 1

In this study, we analysed the effects of an intake of 48 grams of ethanol in the form of draught beer over a period of one hour during which time subjects either drank on an empty stomach or whilst taking light food or partaking of a full meal.

This study revealed that those who drank six glasses of beer in one hour would almost certainly reach or exceed a BAC of 0.05% whether they were fasting or partaking of a meal or light food at the time. The three of the 35 who did not reach 0.05% all weighed more than 83 kilograms. The only other notable correlation was that, if the individual was very light – under 60 kilograms – the BAC was likely to reach the highest recorded levels, but there was no specific correlation in the weight range of 64-76 kilograms.

Study 2

In this study, the subjects were asked to drink 96 grams of ethanol in the form of draught beer (12 standard drinks) over a three-hour period on an empty stomach. There were 12 subjects, but three escaped to the bar area at the end of the experiment, so that there was some doubt about the validity of the readings in these individuals after the three-hour period.

However, all twelve persons reached or exceeded 0.05% after the six drinks in the first hour, and in those nine individuals who could be validly studied, the BAC rose at a steady rate of approximately 0.01% for each standard drink that was imbibed. Again, the higher values of 0.14% were found in those under 60 kilograms in weight, but there was little significant difference between those who weighed between 60 and 70 kilograms.

Study 3

Several beverages were drunk by fasting subjects, but a lower intake over three hours was tried. Four standard drinks were taken in the first hour, followed by two in the second and two in the third.

Of the 15 subjects, 12 remained below 0.5% after the first four drinks. The person who reached 0.05% on four glasses of beer weighed only 57 kilograms. Two subjects drinking four glasses of whisky recorded 0.05% and 0.06% at the end of the hour. These two individuals weighed 67 kilograms and 60 kilograms respectively, but they drank slightly more ethanol than did those who had beer alone. (Spirits – 37 grams, beer – 30 grams.)

All persons drinking eight standard drinks over three hours exceeded 0.05% and, in general, it seemed that in a continuous drinking session of this duration, a person's BAC will be equal to 0.01 grams, multiplied by the number of standard drinks taken during the period, a standard drink being of the order of 8-10 grams of ethanol.

Study 4

Beer and wine were consumed in low dosage over two hours in this experiment. In the first hour, four standard drinks were taken with the full meal and a further two drinks were imbibed in the next hour.

None of the 13 subjects reached 0.05% in this study, although nine showed a gentle rise between the readings after one hour and again after two hours. There was no observable difference between those who drank beer and those who took wine, the ethanol contents of the beverages being the same.

Study 5

A comparison was made between drinking six beers over two hours on an empty stomach and taking the same amount during the course of a meal. Where comparisons could be made, it seemed that values were lower for those who took a meal with the beverage but for subjects weighing up to 80 kilograms the same gentle rise in BAC seen in the fasting group was seen after the second hour (Table II).

TABLE II *Weights and BACs for Two Groups of Subjects Who Drank Six Standard Beers in Two Hours*[a]

Condition	Weight in kg.	BAC (g/100 ml) 1st Hour	BAC (g/100 ml) 2nd Hour
Fasting	57	0.05	0.08
	65	0.03	0.06
	65	0.04	0.06
	66	0.03	0.04
	74	0.04	0.04
	76	0.03	0.05
	86	0.03	0.04
Full Meal	60	0.03	0.04
	64	0.02	0.04
	64	0.03	0.05
	76	0.03	0.04
	79	0.01	0.02
	86	0.02	0.02
	96	0.02	0.02

[a] One standard beer = 210 ml (8 g of ethanol).

COMMUNITY ATTITUDES

During the course of these studies, an attempt was made to discover the attitudes of young men to the question of drinking and driving. Our findings corroborated those of a more extensive community survey of behaviour and attitudes, which was conducted by the Traffic Accident Research Unit in New South Wales and which was published in May, 1973 (3). The survey, conducted in the Sydney metropolitan area, was a random one and included 1,197 males and females between the ages of 17 and 69.

The main findings were as follows:

1. A high percentage of males (mainly young) and a small number of females had combined drinking with driving, some on many occasions.
2. Away from home, the commonest place to drink was in the hotel, where strong group pressures influenced young men to drink excessively. These persons usually drove home afterwards.
3. There was an unawareness of the role of alcohol in traffic accidents and, more particularly, of how much one could drink and still drive safely.
4. Most of the subjects claimed that the drink-driving legislation had not altered their drinking habits.

STUDY OF A SAMPLE OF BREATHALYSED DRIVERS

We also studied a sample of apprehended drinking drivers in order to obtain some appreciation of their drinking habits. Thus during 1973, a sample of 2,000 breathalysed drivers in Victoria was analysed. The age at which a person may legally obtain a licence to drive in Victoria is 18 years.

In this survey it was found that 42 per cent of the apprehended drivers were aged 25 years or under and nearly all were males. In Victoria, only 20 per cent of licensed drivers are in this age group.

Another feature worthy of note is that over 75 per cent of the apprehended drivers were blue collar workers, including the under-25 age group. Also, there is a significant rise in the mean BAC after the age of 21, with the mean BAC at 22-23 being 0.132% and at 36-50 rising to 0.156%.

It is frequently stated that a high BAC probably reflects an alcoholic's pattern of drinking and that those found with values of 0.15% or more should be assessed for possible underlying alcoholism. Our own experience with alcoholics confirms this impression, especially for those over the age of 30. But it is a matter of serious concern that high BACs are being found in younger persons and this is particularly so in males over the age of 22-23. It is difficult to be sure if males up to the age of 23, with high BACs, are established alcoholics or whether they have merely been caught after an episode of explosive drinking. Our experience with an unselected group of convicted drinking drivers, all males under the age of 25, would suggest that explosive drinking among young males occurs during many weekends of the year and that they have a high rate of exposure to driving whilst exceeding the legal limit. It is worth noting that in another study few drivers were detected with BACs as low as 0.05% but that 92 per cent exceeded 0.08% and 75 per cent exceeded 0.15% (2).

Finally, a matter of some concern is the history of previous convictions in the apprehended group of drivers. Dr. K. Jamieson in Queensland observed in a study of casualty accidents in 1964-65, that 20 per cent of the accident group had prior criminal convictions and that they had heavier or more regular drinking patterns than a control group (1). In a follow-up study seven years later, there was anecdotal evidence for the evolution of significant drinking problems among the group and of further criminal behaviour. Those persons involved in a single vehicle casualty accident had the highest criminal record – 60.5 per cent. This figure should be compared to the prevalence of criminal behaviour in the community which is estimated at approximately 12 per cent of adult males.

Anne Raymond (2) noted that of the breathalysed drivers in a survey which she conducted in 1967, 35 per cent had previous criminal convictions. In our own sample of young drivers under the age of 25, undergoing a rehabilitation course at St. Vincent's Hospital, 26 per cent of the group had prior criminal convictions.

One wonders whether the anti-social behaviour of many, if not most, of these individuals is triggered off by an excessive alcohol intake prior to the criminal offence, and that a road accident for these individuals is simply an episode in a long line of anti-social activities associated with heavy drinking sessions. This proposition warrants further consideration, especially if we propose to run rehabilitation courses for these people, and more particularly, if we propose to introduce other preventive programmes. It is our impression that it may be possible to modify the drinking and driving behaviour of young people up to the age of 25 by an educational programme. However, after the age of 25, drinking drivers apprehended and found to have high BACs may be established alcoholics for whom a simple educational programme would be insufficient. Moreover, if drink-driving is an expression of sociopathic or psychopathic tendencies in an individual, it may be necessary to conduct other forms of therapy aimed at behaviour modification in these persons.

We are currently exploring these aspects of what should now be regarded as a serious public health problem.

CONCLUSION

This paper outlines the results of a series of experiments designed to determine BACs in a variety of drinking situations. It would appear that a loading dose of 48 grams of ethanol in one hour would cause the BAC to exceed 0.05% whether the individual is fasting or eating. Eight to 10 grams of alcohol causes the BAC to rise by approximately 0.01% and a continued intake of 16-20 grams per hour will result in a rising BAC. The weight of the individual is of importance only when comparisons are made between persons who are at opposite extremes of the weight range.

REFERENCES

1. Jamieson, K. G., Sociology of the Accident Involved. *Proceedings of Symposium on ' 'Road Safety and the Law",* Australian Department of Transport, Sydney, 1973.
2. Raymond, A., Characteristics of Breathalysed Drivers. *Proceedings of the National Road Safety Symposium,* Department of Shipping and Transport, Canberra, 1972.
3. Traffic Accident Research Unit – N.S.W., *Drinking and Driving in Sydney: A Community Survey of Behaviour and Attitudes,* 1973.

Medical Conclusions from the Clinical Tests of Drunken Drivers with High Alcohol Levels

Artur Solarz[1]

Many papers have been published concerning the correlation between clinical tests of suspected drunken drivers and the laboratory results of analyses of alcohol in blood and urine. The views on this matter vary substantially, ranging from negative criticism (2, 3, 9, 10, 12, 13, 14, 19, 20) to positive (14, 18); there is even a suggestion of making such clinical examinations obligatory (1).

One of the first papers on clinical tests was published by Liljestrand (13). He found that the results obtained by seven different physicians, when examining the same persons, differed widely. In another study Bonnichsen *et al* (9) used case material of drivers who had been examined by 800 different physicians and 244 cases where one and the same physician had carried out all examinations. The results showed extreme variations, even where the medical investigation had been made by one physician only. Kataja *et al* (11) found it possible to estimate blood alcohol concentrations based on clinical test results. Goldberg (8) concluded that clinical examination gives 100 per cent positive findings only in cases with a high blood alcohol concentration (BAC) (0.2-0.3 g/100 ml). Below 0.15-0.20 g/100 ml there will always be individuals who 'stand' a routine examination. Pentillä *et al* (17) examined 42 persons with a BAC over 0.3 g/100 ml. All were found to be under the influence of alcohol and 78 per cent of them were found to be at least moderately intoxicated.

TYPE OF DATA

The main question asked in this study was whether the medical test is, in general, relevant in the determination of the degree of intoxication. I have therefore tried to trace the legal and criminological aspects of this problem.

Sweden provides one advantage for performing such an investigation. There is only one central laboratory that analyses alcohol from suspected drunken drivers. The samples are analyzed by the same methods under similar conditions and with the same equipment. The data are uniform, since the protocol forms which accompany the blood samples used by the police and by the physicians are the same for the whole country.

The research material includes information referring to the personal data, the observations of the police concerning the driver's sobriety, the results of the alcotest, the observations under the medical examinations and the doctors' conclusions about the degree of drunkenness. Consequently, this paper is limited to some basic data concerning the doctors' final opinion as opposed to tests of alcohol level in blood and/or urine. For the purposes of this study the alcohol concentration of 0.3 g/100 ml of blood (after the allowance of 0.014 g/100 ml)[2] and 0.4 g/100 ml of urine has been adopted as a high level. The clinical examination is similar to those in other countries and the final conclusions are given in the form of the following estimations: the subject is slightly, moderately, highly or not at all under the influence of alcohol. The conclusions can also indicate that the subject is under the influence of other drugs, ill, tired or sleepy.

---

[1] National Laboratory for Forensic Chemistry, 104 01 Stockholm, 60 Sweden.

RESULTS

During 1973, 21,711 laboratory analyses of blood alcohol were performed in Sweden. In 100 of these cases the alcohol level was 0.3 g/100 ml or more in blood (reduced level[2]) and in 546 instances 0.4 g/100 ml or more in urine. In these 646 cases the clinical conclusions were compared to the actual levels. The results are presented in Tables I, II and III.

TABLE I *Doctors' Conclusions and BACs in 546 Cases where the Urine Alcohol Level was 0.4 g/ml or More*

		BAC (after the allowance) in g/100 ml			Doctors' conclusions from the medical examinations							
							Under the influence of alcohol:					
Age group	No. of cases	.150-.200	.210-.250	.251-.299	No conclusion	Not under the influence of alcohol	slightly	moderately	highly	slightly/moderately	moderately/highly	without indicating the degree of drunkenness
		No. of cases										
15-17	–	–	–	–	–	–	–	–	–	–	–	–
18-20	3	–	1	2	–	–	–	3	–	–	–	–
21-40	346	5	118	223	1	8	73	171	62	12	9	10
41-50	144	–	42	102	1	2	40	71	21	7	1	1
51-60	39	1	14	24	–	2	3	17	11	2	3	1
61-	14	–	3	11	–	1	2	7	3	–	–	1
Total	546	6	178	362	2	13	118	269	97	21	13	13

TABLE II *Doctors' Conclusions and UACs in 100 Cases where the BAC was 0.3 g/100 ml or More*

		UAC in per cent			Doctors' conclusions from the medical examinations							
							Under the influence of alcohol:					
Age group	No. of cases	No data	Below 0.4%	Above 0.4%	No conclusion	Not under the influence of alcohol	slightly	moderately	highly	slightly/moderately	moderately/highly	without indicating the degree of drunkenness
		No. of cases										
15-17	–	–	–	–	–	–	–	–	–	–	–	–
18-20	1	1	–	–	–	–	–	–	–	–	–	1
21-40	62	9	9	44	2	1	4	23	24	1	4	3
41-50	22	4	–	18	2	–	2	8	9	–	1	–
51-60	13	2	–	11	1	–	–	5	7	–	–	–
61-	2	–	–	2	–	–	–	1	1	–	–	–
Total	100	16	9	75	75	1	6	37	41	1	5	4

[2] The allowance of 0.014 g/100 ml is made to compensate for a possible error in the analyses. In some instances when the results do not agree sufficiently to allow the calculation of a mean value, e.g., when the results of the determinations differ considerably, additional determinations can be made and a higher allowance is then calculated.

Thus, in 21 per cent of the analyzed cases the conclusion was that the subject was not under the influence of alcohol or that he was slightly inebriated; in 47.5 per cent of the cases that the subject was moderately intoxicated; and only in 21.5 per cent that the subject was highly intoxicated. Even when taking into consideration the 2.8 per cent in which the results were equivocal, namely moderately or highly influenced by alcohol, we come to the conclusion that in only about 25 per cent of the studied cases the doctors' observations from clinical tests about the degree of drunkenness correlated with the degree of intoxication expressed by the alcohol level in blood and/or urine.

TABLE III *Doctors' Conclusions in the 646 Studied Cases*

		Doctors' conclusions from the medical examinations							
Age group	No. of cases	No conclusion	Not under the influence of alcohol	Under the influence of alcohol:					
				slightly	moderately	highly	slightly/moderately	moderately/highly	without indicating the degree of drunkenness
15-17	–	–	–	–	–	–	–	–	–
18-20	4	–	–	–	3	–	–	–	1
21-40	408	3	9	77	194	86	13	13	13
41-50	166	3	2	42	79	30	7	2	1
51-60	52	1	2	3	22	18	2	3	1
61-	16	–	1	2	8	4	–	–	1
Total	646	7	14	124	306	138	22	18	17

DISCUSSION

The results obtained in this study indicate that the symptoms of alcohol intoxication do not run parallel with a high alcohol concentration. Steigleder (10) who examined 18,000 cases arrived at similar conclusions. Among 374 cases with an alcohol level of more than 0.26 g/100 ml there were only 104 (*i.e.*, 27.8 per cent of the 374 cases studied) in which the doctors' conclusions correlated with the degree of intoxication expressed by the results of the analyses.

There are many variables affecting medical conclusions which doctors cannot or do not notice. As shown by several authors (1, 6, 8, 12, 16) the clinically observed symptoms of drunken subjects are more noticeable in the phase of increasing drunkenness than in the phase where the blood alcohol is decreasing. Also, persons with a developed tolerance for ethanol are likely to show fewer outward signs of drunkenness (3). In addition, the degree of intoxication may show not only daily variations, but may be affected by a number of factors, such as nutrition, sleep and fatigue. Training, the intellectual level, the psyche as well as the bodily constitution, must be taken into account (7, 8, 15).

A physician is likely to offer subjective views which is another reason why the results obtained showed variability. (13, 15).

The above mentioned aspects could be sufficient to weaken the value of taking medical conclusions on the degree of drunkenness as evidence. However, there are some legal and criminological aspects, which have to be considered.

The principal privilege an expert enjoys is that he can give an opinion and a conclusion, which a lay witness under the law cannot. However, there are some conditions that an expert should satisfy. The most important among them are that he has to draw conclusions based on facts, never on conjecture or speculation. An expert should also be capable of showing grounds for the conclusions reached and the opinions of different examiners based on the same material should be comparable. Unfortunately, the subjective nature of the evaluations made by the doctors make the conclusion about the degree of drunkenness of scant legal use as scientific evidence.

The rules regarding offences of drunken driving now in force in Sweden are based on the following principles. The very act of driving a motor-vehicle when the driver is affected by alcohol is punishable irrespective of whether an accident has been caused. Further, two pro mille limits of 0.5 pro mille or more and of 1.5 pro mille or more have been fixed. If the driver has an alcohol level in his blood of 1.5 pro mille or above, he is assumed to be intoxicated and not fit to drive. In such cases the usual penalty is imprisonment. If the alcohol concentration in his blood is between 0.5 pro mille and 1.5 pro mille the penalty will be a fine or imprisonment.

According to the opinion of the Government Committee to review the legislation concerning driving when under the influence of alcohol "a fixed promille level must be regarded as an advantage from the point of view of prevention and of equality before the law" (21). This means that the fixed promille level is based on a general assessment of the road accident risks which, in general, exist at the BAC indicated by the given promille level. In other words: a) A person can be regarded as impaired when the BAC has been stated on the basis of a laboratory test and exceeds 0.05 g/100 ml, even though this might not clearly be perceptible from external observations (5). b) A driver who can tolerate alcohol has to obey the law in the common interest.

In this light the medical conclusions based on the clinical tests play a very limited role as evidence used to estimate the degree of drunkenness. This has been confirmed by the results of the study of court records of 75 cases for drunken driving. The laboratory tests were used as evidence to support the charges or the verdicts, irrespective of the contents of the medical conclusions about the degree of drunkenness.

Finally, one of the criminological aspects of the problem presented here should be pointed out. It is frequently said that one of the important aims of sentencing is not only to prevent others from committing a similar offence, but above all to play a correctional function. Therefore the way in which the legal proceedings have been performed is not irrelevent. An important part of satisfying the correctional function of the sentencing is that the offender should be convinced of his guilt. It is not difficult to imagine that the offender will not be convinced unless the evidence has been clear and cogent. Such a situation of doubt may happen when two opposite opinions are presented in the court (for instance the doctor's conclusion that the subject has not been influenced or only slightly influenced by alcohol and another opinion, the result from the laboratory test indicating a high level of alcohol in blood and/or in urine). Since neither the prosecutor nor the judge give reasons for their evaluation of the evidence, it can be assumed that in many cases the correctional function of the verdict can be uncertain.

CONCLUSIONS

The results obtained in this study indicate that the external symptoms of alcohol intoxication vary, even when the BAC is high. The medical conclusion based on these symptoms may be affected by personal causes and by the subjective nature of the physicians' evaluation. These conclusions may be questionable when used as scientific evidence to estimate the degree of drunkenness. There are, however, other aspects which have to be considered. The need for a medical examination can be, for example, justified in order to discover if there was any cause other than drinking, which could account for peculiar behaviour and impaired driving of the suspected person (for instance driving under the influence of other drugs). These aspects of the medical test, however, have not been taken into consideration in this study.

REFERENCES

1. Alha, A. R., *Blood Alcohol and Clinical Inebriation in Finnish Men,* Suomalainen Tiedeakatemia, Helsinki, 1951.
2. Andrèasson, R. and Bonnichsen, R. Ergebisse klinischer Untersuchungen bei verschiedenem Blutalkoholhalt, *Blutalkohol* 2, 485 (1964).
3. Bonnichsen, R., Dimberg, R., Meahly, A. and Åqvist, S. *Alkohol och påverkan.* (Summary in English). Meddelande nr. 17, Institut för maltdryckforskning, Stockholm, 1967.
4. Bonnichsen, R., Dimberg, R., Meahly, A. and Åqvist, S. Die Alkoholverbrennung bei Alkoholiken and übrigen Versuchspersonen, *Blutalkohol* 5, 301 (1968).
5. Cosmo, C-J., The Swedish Legislation Regarding Traffic Sobriety Offences, *Blutalkohol* 10, 300 (1973).
6. Gerchow, J. and Sachs, V. Die gesetzmässigen Beziehungen zwischen Alkoholkonzentration, Zeit and klinisch feststellbarer Trunkenheit. *Deutsche Zeitschrift für die Gesante Gerichtliche Medizin.* 51, 32 (1961).
7. Goldberg, L., Alkoholpåverkan vid olika grader av vänjning, *Tirfing* 3 (1944).
8. Goldberg, L., Tolerance to Alcohol in Moderate Drinkers and its Significance to Alcohol and Traffic. In *Proceedings of the 1st International Conference on Alcohol and Road Traffic,* Kugelbergs Boktryckeri, Stockholm 1951.
9. Heifer, U., Untersuchungen über die Wertigkeit von Alkoholwirkungs-Merkmalen, *Blutalkohol* 2, 244 (1963).
10. Haase, D., *Statistische Untersuchungen über die Beziehungen zwischen Blutalkoholkonzentration und ärztlich festgestellten äusseren Symptomen der Alkoholwirkung.* (Diss.), Bonn, 1955.
11. Kataja M., Penttilä, A., Tenhu, M. and Uotila, U. Die Vorhersage des Blutalkohols auf Grund der klinischen Befunde bei präsumptiven Verkehrsbetrunkenen, *Blutalkohol* 9, 451 (1972).
12. Krauland, W., Rose, C. and Freudenberg, K. Blutalkoholkonzentration und ärztliche Diagnose, *Blutalkohol* 2, 514 (1963).
13. Liljestrand, G., Till frågan om läkarundersökning rörande alkoholpåverkan, *Tirfing* 34, 97 (1940).
14. Liljestrand, G., Discussion. In *Proceedings of the 1st International Conference on Alcohol and Road Traffic,* Kugelbergs Boktryckeri, Stockholm, 1951.
15. Maglajlic, A., Alcohol, Alcoholism, Alcoholemia and Drivers. In *Proceedings of the Third Triennial Congress on Medical and Related Aspects of Motor Vehicle Accidents,* The University of Michigan. Highway Safety Research Institute, Ann Arbor, Michigan, 1971.
16. *Nykterhet i trafik. SOU:1963:72,* Iduns Tryckeriaktiebolag Esselte AB, Stockholm, 1963.
17. Penttilä, A., Tenhu, M. and Kataja, M. Computer Analysis of Clinical Test Correlations with Blood Alcohol and the Physicians Final Evaluation of the State of Intoxication in Cases of Suspected Drunken Driving, *Blutalkohol* 9, 104 (1972).
18. Penttilä, A., Tenhu, M. and Kataja, M. Das Vorkommen von hohem Blutalkoholgehalt (über 3‰) bei im Strassenverkehr angetroffenen Personen, *Blutalkohol* 9, 45 (1972).
19. Rasch, W., Wert und Verwertbarkeit der sogenannten klinischen Trunkenheitsuntersuchung, *Blutalkohol* 6, 129 (1969).
20. Steigleder, E., Statistische Auswertung der Dokumentation gerichtsmedizinischer Blutalkoholbefunde aus Schleswig-Holstein, *Blutalkohol* 5, 573 (1968).
21. *Trafiknykterhetsbrott, SOU 1970:61,* Esselte Tryck, Stockholm 1970 (Summary in English on pp. 361-377).

Alcohol, Drugs, and Driving Behaviour in Switzerland

P. Kielholz[1,2]

A series of tests concerning the effect of alcohol on traffic accidents were carried out in 14 hospitals located in seven different parts of Switzerland by the Swiss Commission against Alcoholism. From a total of 1,030 hospitalized persons injured in traffic accidents, 35.2 per cent were found to be under the influence of alcohol and 21.1 per cent of the whole sample had blood alcohol levels of or above 0.8‰ (Swiss statutory limit). These 21.1 per cent are divided into different groups of road users in Figure 1.

The highest percentage of road accident victims who were under the influence of alcohol was found among the bicyclists and motor-cyclists, followed by the motorists. The comparison with those injured in sports accidents (3.9 per cent showed an alcohol content of or above 0.8‰) and those injured in working accidents (4.3 per cent showed an alcohol content of or above 0.8‰) is particularly impressive. The blood alcohol tests of road accident victims clearly show that the dark figure in official statistics must be very high.

Precise statistical evaluation concerning the frequency of driving under the effect of medication is not available. Verification methods, in particular the quantitative analysis of many drugs and their metabolites, are not well enough developed for routine application. Furthermore they are very expensive and therefore are only applied in cases of reasonable suspicion. Four per cent of 328 road accident victims in a Swiss survey revealed drugs in the urine (2). In a series of tests of 6,200 road accident victims carried out by Forney (1), 4 per cent were found to have centrally stimulating prescription drugs in their blood and urine.

Statistics clearly show that alcohol is the most common intoxicant involved in road accidents. We found that the ratio of alcohol to medication is 8 : 1 (3). Driving

---

[1] Director, University Psychiatric Clinic, Wilh. Klein Str. 27, Basle, Switzerland.

[2] This paper was also presented graphically by means of a short film entitled Alcohol, Drugs and Driving Behaviour.

[3] This research was carried out with the co-operation of Prof. L. Goldberg, head of the Institute for Theoretical Alcohol Research, Karolinska Institute, Stockholm; Prof. J. Im Obersteg, Institute for Forensic Medicine, University of Basle, Basle; J. Bäumler, M.D., public analyst, Basle; Captain A. Ramseyer and Captain A. Maritz, Department of Traffic for the Cantonal Police of Basle City; G. Reggiani, M.D., Basle; W. Pöldinger, M.D., Wil/SG and P. Schmid, M.D., statistician, ETH, Zurich. The investigations were supported by the Swiss National Fund.

tests with 320 voluntary members of the Basle City Police Corps revealed that with a blood alcohol concentration of 0.8‰ a 130 per cent increase in the number of severe driving faults could be observed[3] (Figure 2).

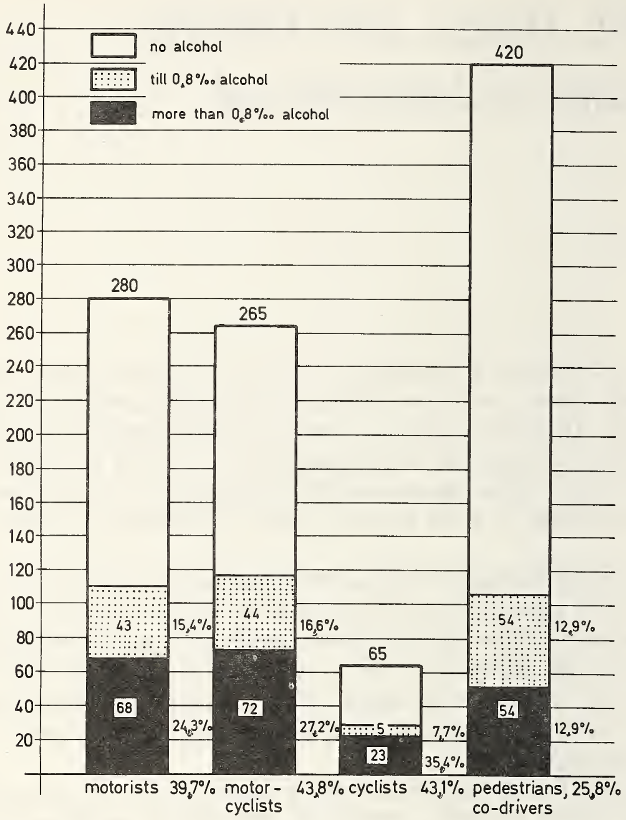


Figure 1 *Hospitalized road users from 1,030 accidents found in 14 hospitals situated in Wallis, Baden, Tessin, Neuchâtel, Luzern, Lausanne and St. Gallen. Copyright by Psychiatrische Universitätsklinik, Basle.*

The main danger of the psychotropic drugs is not their own effect but their intensifying effect on alcohol. That doubling the therapeutic dose of a tranquillizer does not cause a significant increase of severe driving faults is shown by our investigations. However, severe faults are clearly intensified by the combined effect of alcohol and drugs. Psychotropics can impair the driving capacity in the following three ways: 1) by having a direct influence on driving capacity through sleepiness, numbness, and neurological side effects; 2) by altering the personality through acute or chronic intoxication or through abstinence after states of drug dependence; and 3) by intensifying the effects of alcohol. Psychotropic drugs, in particular those with a combating, hypnotic effect like the main neuroleptics, anti-depressants and tranquillizers, ordinarily have an impairing effect on driving ability only in the beginning *i.e.*, in the first 10 to 14 days. By an adaptation to the pharmacogenic symptoms of fatigue, and by the

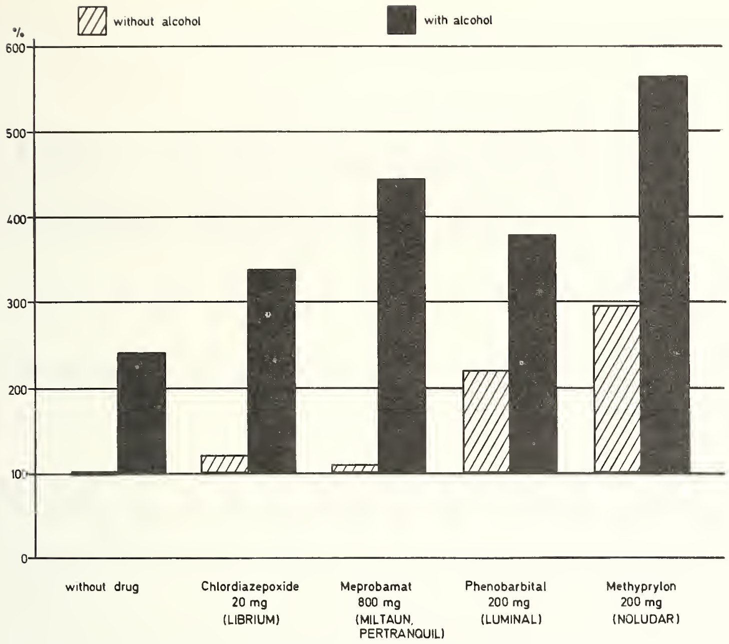


Figure 2 *Effects of alcohol with and without other drugs in the driving of police volunteers. Copyright by Psychiatrische Universitätsklinik, Basle.*

knowledge of the individual responses and side effects, as well as by improvement of the physical inconveniences, the driving ability can often be improved. The chief danger of the psychoactive drugs, as should be pointed out to every patient on long-term drug therapy, comes from the potentiating effect of alcohol on the drug.

REFERENCES

1. Forney, R. B., International Seminar Research on Alcohol, Drugs and Driving. *Pharmakopsychiatrie Neuro-Psychopharmakologie* 6, 104-114 (1973).
2. Im Obersteg, J. and Bäumler, J., Unfälle unter der Wirkung von Arzneimittel und Alkohol. *Schweizerische Medizinische Wochenschrift* 97, 1039-1042 (1967).
3. Kielholz, P. and Hobi, V., Beeinflussung der Fahrtüchtigkeit durch Psychopharmaka. *Therapeutische Umschau* 31, 606-613 (1974).

The Effect of Alcohol on Human Information Processing Rate

Herbert Moskowitz[1] and James Murray

Epidemiological data indicate that the presence of alcohol greatly increases the probability of accidents in driving. It is not clear what behavioral mechanisms are affected by alcohol to produce the impairment of skills performance which underlies these accidents.

It has been suggested that the impairment of skills performance by alcohol, especially at lower dose levels, occurs due to effects on central information processes rather than peripheral sensory or motor mechanisms (4). Evidence that one of the central factors affected by alcohol is the rate of information processing is supported by studies demonstrating an increase in response latency under alcohol when conditions demand processing of considerable information from the stimulus configuration (5, 7). While these studies included controls to demonstrate that the increased latencies could not be ascribed solely to sensory and/or motor factors, the relative contribution of sensory, motor and central mechanisms to the latency increases could not be separately determined.

The present study employs the technique of backward masking of a visual stimulus to give a more direct estimate of the effect of alcohol on one stage of central information processing time without confounding by sensory or motor processing delay.

The technique is based upon recent research which presents strong evidence that there are three memory systems within the human organism, a very brief sensory information storage system known also as iconic memory, a short-term memory system (STM), and a long-term memory system (3, 9). Typically, when a visual stimulus is present briefly (in a range of under 200 msec) the subjective duration is longer than the physical stimulus duration due to iconic memory, which can be conceptualized as a rapidly fading visual image. The duration of this image depends on various factors, such as the character of the pre- and post-stimulus visual fields, but typically lasts less than one second (10). If the information contained in the visual image is to be retained further, it must be transformed into the form necessary for retention by the STM system, which does not store information visually (3).

Readout of information from the sensory information store into STM requires time. The length of time required can be determined by use of the backward masking technique. In this technique, the visual target stimulus (TS) is presented very briefly

---

[1] School of Engineering, University of California at Los Angeles, Los Angeles, California 90024.

(15 msec) and is followed after some inter-stimulus interval (ISI) by a visual masking stimulus (MS) which interferes with the visual image of the first stimulus and thereby stops the transfer of TS data into STM. Since the MS interferes with the visual image of the TS, the time available for reading out the information in the visual image is the period from onset of TS to onset of MS, *i.e.*, the ISI plus the TS duration, which is then the effective or subjective duration of the visual image. By varying the ISI and determining the relative amounts of information readout of the image, the rate of this stage of information processing is measured.

This study compared the effects of three dose levels of alcohol upon the amount of information readout of the visual image. The possibility that any change in performance could be due to an effect upon sensory input was controlled by two factors. Since any delay of sensory transmission time by alcohol would affect the TS and MS equally, leaving the effective duration of the TS unchanged, such an effect would not confound the results. Secondly, a condition was included where no MS followed the TS, which gives the subject more than ample time to read out all the information contained in the TS. Under the no-mask condition, any evidence of impairment of performance by alcohol would indicate the presence of another source of alcohol impairment than a decrement of central processing time. Thus it controls for both sensory and motor confounding factors as well as against a possible effect on short-term memory.

METHOD

The subjects were 12 males, aged 21-32 years, with 20/20 vision corrected or uncorrected.

Stimuli were presented in a 3-field tachistoscope with a 91.44 cm viewing distance. The test stimulus card was presented in one field, the masking stimulus card in the second field, and the third field contained a card with a fixation point.

Test stimuli were white cards with four black capital letters in a 10.8 cm wide horizontal row subtending 6.8 degrees of visual arc. Letters for each card were chosen at random without replacement from the alphabet excluding vowels and Y's. Four hundred cards provided the set of test stimuli. The MS was a white card with a high density random array of letters and letter fragments. This 'visual noise' masking stimulus is effective in interfering with further processing of the preceding TS in backward masking situations. The adaption field contained a card with a centered cross for use as a fixation point. Luminance in all fields was 15 footlamberts.

Procedure

The experimental procedure began with the subject fixating on the cross of the adapting field. When the subject was ready, the adapting field was replaced with a 15 msec presentation of the test stimulus, followed by a dark interval of variable duration (ISI), followed in turn by a 500 millisecond masking stimulus.

Subjects responded to each trial by writing four letters on a specially prepared answer sheet. They were required to guess when unsure. Only those letters in the correct positions in the row were counted as correct.

Six ISIs were employed: −15, 15, 30, 45, 60 and 75 msec plus a condition in which the TS was presented without MS. The −15 msec ISI condition, where both the TS and MS were presented simultaneously, was employed to demonstrate that MS did prevent the processing of the material in TS. These seven conditions were presented in blocks of 12 trials each. Subjects received one ascending and one descending series for a total of 168 trials. Half of the subjects received the ascending series first and half received stimuli in the reverse order. The first two trials of each block were warm-up trials and data were examined only for the last ten trials.

Prior to any test sessions, subjects received two training sessions to minimize variability in performance. Subjects participated in three test sessions, one for each treatment, at one-week intervals. At each session subjects received a beverage containing either 0, 0.414 or 0.828 grams of alcohol per kilogram bodyweight in a beverage containing sufficient orange juice to produce a volume of one ounce per 12.5 pounds bodyweight. Two subjects were randomly assigned to each of the six possible treatment orders.

Subjects were instructed not to eat for four hours preceding a test session. They were required to drink the beverage within 30 minutes; testing began 30 minutes after the subject finished drinking. The experimental task lasted approximately 30 minutes.

RESULTS

Mean scores of each treatment at each ISI are graphed in the Figure. Data were analyzed with a UCLA Biomedical Analysis of Variance Computing Program (1).

In conformity with the literature on backward masking the results demonstrate that the length of time available for processing the visual information storage image (as set by the ISI length) determined the amount of information readout.

Figure 1 indicates that alcohol produced a slowing of the rate at which information was read out of the sensory information storage. At all ISIs where the MS was presented and the response rate was above the guessing level, fewer letters were correctly reported under the alcohol treatments ($F = 42.17$, $df = 2, 10$, $p < 0.01$). The mean curves presented in the Figure are characteristic of individual curves. Only one of the 12 subjects failed to show performance impairment under the lower alcohol dosage and all showed impairment under the higher alcohol dosage.

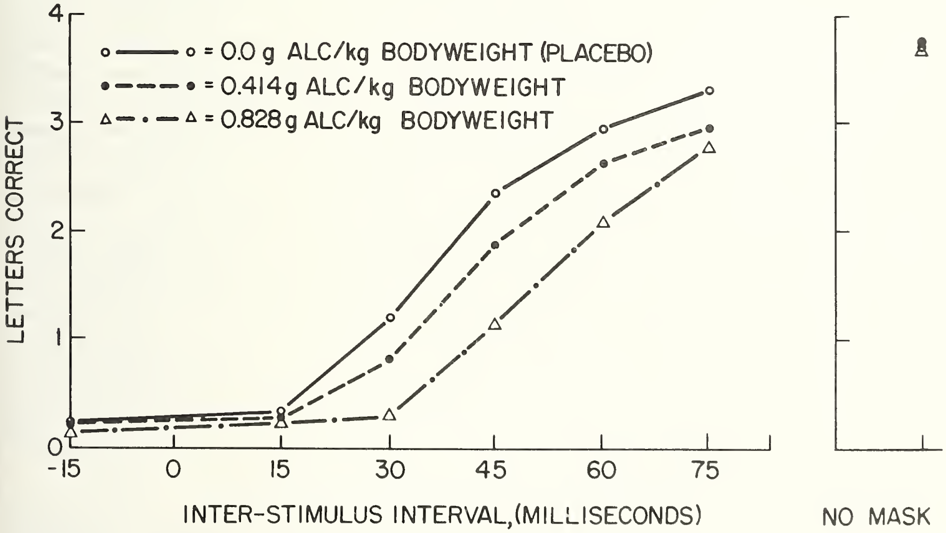


Figure 1 *Mean scores of three treatments at six inter-stimulus intervals.*

The Figure suggests that the increment in performance as the ISI increased was roughly the same for all treatments. This was confirmed by a non-significant interaction term, Treatments X ISI, for all ISIs where performance was above guessing level, *i.e.*, 30 to 75 msec (F = 2.51, df = 6, 6, not significant). The .414 g alcohol/kg bodyweight dose increased processing time about 5 to 7 msec and the .828 g alcohol/kg bodyweight dose increased processing time about 15 to 20 msec. Thus the effect of the alcohol treatment appeared primarily upon the intercept of the curves rather than upon the slope.

It should be noted that the alcohol treatments had no effect on information processing where ample time was permitted for processing, that is, in the condition where no mask was presented (F = 0.44, df = 2, 10, not significant). Thus in this experimental situation there was no impairment of sensory or motor performance, only of central processing.

DISCUSSION

The decreased number of correctly reported letters under the alcohol treatments supports the hypothesis that alcohol impairs the rate of information processing, at least for the function of reading information of the sensory storage image into STM. The degree of deficit found for alcohol upon information processing time reflects alcohol's influence only upon readout from the iconic image. It does not indicate an alcohol effect upon other links in the information processing chain. There well may be other information processing steps important for safe functioning in driving which are equally susceptible to the influence of alcohol.

This experiment was one of a series which have been undertaken to determine the nature of alcohol impairment of skills performance. In several previous studies, it was found that performance requiring division of attention between two or more information inputs was uniquely sensitive to alcohol impairment at blood alcohol levels beginning at .015% (2,4,6,8,11). The results of this study suggest one possible mechanism underlying the sensitivity of divided attention performance to alcohol. This explanation is dependent on the assumption that while divided attention appears to be a parallel processing of information from diverse sources, microanalysis of the phenomenon suggests that it is a process involving serial processing of information sampled alternately from the various sources, except when information processing demands are very low. For such a serial sampling process to occur, a large capacity information storage buffer is required to hold the data from various channels while data is being processed more centrally from alternate channels. It is this function which the sensory information storage image is presumed to perform. Under these circumstances any delay in processing the information from one channel will result in a loss of information from the other channels which are being held in the short-lived sensory information storage. Thus a slowed rate of information processing will produce a decreased capacity to handle information from more than one channel if the quantity of information is beyond the capacity for parallel processing.

However, even in situations where the amount of information to be processed does not require serial processing, the increase in processing time represents a danger in driving situations where a rapid response to threatening stimuli is required.

REFERENCES

1. Dixon, W. J. (ed.), *Biomedical Computer Programs.* University of California Press, Los Angeles, California, 1973.
2. Hamilton, P. and Copeman, A., The Effect of Alcohol and Noise on Components of a Tracking and Monitoring Task, *British Journal of Psychology* 61, 149 (1970).
3. Keele, S. W., *Attention and Human Performance.* Goodyear Publishing Co., Pacific Palisades, California, 1973.
4. Moskowitz, H., Laboratory Studies of the Effects of Alcohol on Some Variables Related to Driving, *Journal of Safety Research* 5, 185 (1973).
5. Moskowitz, H. and Burns, M. The Effect of Alcohol upon the Psychological Refractory Period, *Quarterly Journal of Studies on Alcohol* 32, 782 (1971).
6. Moskowitz, H. and DePry, D. The Effect of Alcohol upon Auditory Vigilance and Divided Attention Task, *Quarterly Journal of Studies on Alcohol* 29, 54 (1968).
7. Moskowitz, H. and Roth, S. The Effect of Alcohol upon the Latency in Naming Objects, *Quarterly Journal of Studies on Alcohol* 32, 969 (1971).
8. Moskowitz, H. and Sharma, S. Effects of Alcohol on Peripheral Vision as a Function of Attention, *Human Factors* 16, 174 (1974).
9. Neisser, U., *Cognitive Psychology.* Appleton-Century-Crofts, New York, 1967.
10. Sperling, G., The Information Available in Brief Visual Presentations, *Psychological Monographs* 74, 1 (1960).
11. Von Wright, J. M. and Mikkonen, V. The Influence of Alcohol on the Detection of Light Signals in Different Parts of the Visual Field, *Scandinavian Journal of Psychology* 11, 167 (1970).

The Influence of Small Doses of Alcohol on the Rate of Decision Making

Paul Verhaegen[1,2], Etienne van Keer and Roger Gambart

One afternoon, a few years ago, one of the authors was driving a Volkswagen minibus with 8 young children in it along a crowded three-lane single carriageway with fairly fast moving traffic. In order to enter the secondary road to his home he had to turn left. Thus he slowed down and began to leave the right-hand lane, marked by an unbroken white line, so that he could stop in the middle lane to wait for a gap in the oncoming traffic. All at once, he saw in the driving mirror, at perhaps 200 meters behind him, an ambulance swiftly leave the right lane and drive at high speed along the middle lane, left of the unbroken white line, overtaking the vehicles progressing in the right lane[3].

The driver's immediate thought was to give way to the ambulance, to pull back into his place in the right lane and eventually make his left turn at the next road junction. However, when he started to re-enter the right lane he heard the horn of a car that was already overtaking him on his right. Consequently he decided to discontinue this manoeuvre and to redirect the car to the middle lane of the carriageway and to stop there. This would either oblige the ambulance to stop and to lose some time or, as was the actual case, to slip into the right lane behind the minibus again.

This incident could easily have developed into a serious accident. The resolution made by the minibus driver was that in the future he would not let himself be influenced so easily by irregular behaviour of ambulances.

We think this critical incident is interesting. Within five seconds the driver had to change his mind at least three times; he had to make decisions and then reverse them;

---

[1] Department of Psychology, Catholic University of Leuven (Louvain), Tiense straat 102, B-3000 Leuven, Belgium.

[2] This work was partly supported by the 'Fonds voor Kollektief Fundamenteel Onderzoek' (grant 10, 170).

We are grateful to N. Bovens and Marie Jaubin-Cober who elaborated the computer programmes.

[3] This is of course a clearly illegal way of driving. During the last few years there have been in Belgium some fatal accidents caused by ambulances and police cars that tried to gain a few minutes by breaking elementary traffic rules by not stopping before red traffic lights or by crossing white unbroken lines.

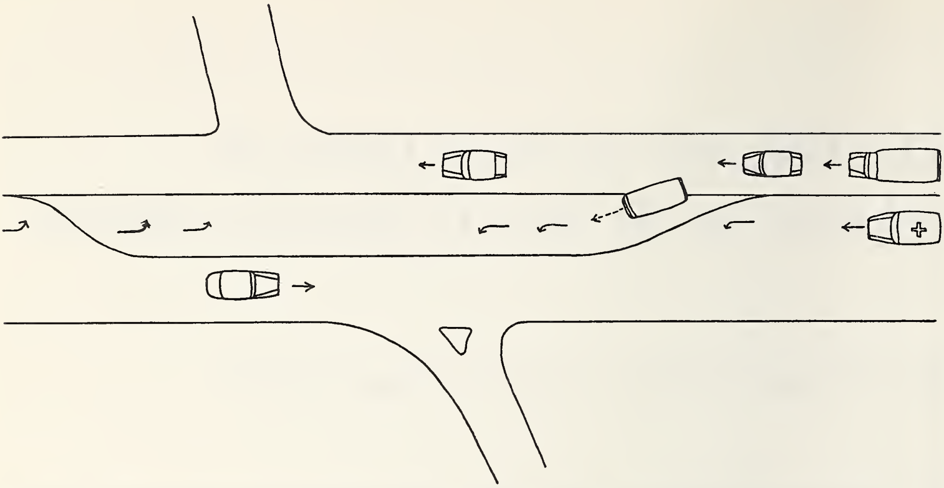


Figure 1 *Driving situation characterized by a high rate of information processing. information processing.*

and he had to start and reverse his actions accordingly. Luckily, in this case he was able to make the relevant decisions or to choose the right responses at a high speed.

Thinking about such incidents in general, we wondered whether the capacity to make decisions, and to take action, would not be hampered by alcohol, even in very small amounts? This seems probable because, within our information transmission system, the decision making system is something like a bottle-neck. Broadbent calls it a 'limited capacity system' (1). We have looked into this question by using exploratory field research and a laboratory experiment.

In principle we were interested in alcohol doses that are lower than those eliciting a blood alcohol concentration (BAC) that makes driving illegal. Nevertheless, as it turned out, it was not possible to do field research concerning such small dosages.

The field research will be reported here very briefly. The laboratory study will be treated more extensively.

AN EXPLORATORY FIELD RESEARCH

One of us (R.G.) had the opportunity to interview a series of 105 drivers in 1973, who had been involved in one or more accidents while under the influence of alcohol. Their ages ranged from 19 to 54 years with a mean of 36. It was possible to interview them in a strictly confidential setting. The aim of the interviewer was to get an insight into each accident and to make a final appraisal concerning the nature of its main 'cause'. The idea was that an inability to process complex information in a critical traffic situation might have been a factor in accident causation. The conclusions of the interviews are summarized in Table I.

These conclusions make the idea that information overload may be a causal factor in accidents where alcohol is involved highly plausible. Information overload is, without doubt, also an important factor in accidents by sober subjects as shown by Fergenson (5). Because we had no control group, we cannot decide whether this factor becomes more important under the influence of alcohol.

TABLE I *Main 'Causes' in 105 Traffic Accidents*[a]

Main 'cause'	Number of accidents in which the cause was present
Slow reaction	40
Tracking error	26
Information overload	16
Fast driving	16
Dangerous action of another driver	11
Unsafe behaviour	11
Insufficient intake of information	9
Insufficient steering movements	7
Sleeping	5
Exaggerated steering movements	5
Absence of reaction	3
Deliberate causation of an accident	1
Incorrect estimation of distances	1

[a] Main 'causes' were determined by interview in 105 traffic accidents in which at least one of the drivers was under the influence of a high alcohol dose.

Further, in the group studied, the BACs were too high with respect to the general aim of our study. The mean BAC from 79 subjects was 218 mg/100 ml. The standard deviation was 58 mg.

Finally, the taxonomy we used to classify the 'causes' of accidents can be discussed. Most of the 'causes' are in some way related to information processing. It seems to us that the concept of 'information overload' must be limited to situations in which too much information must be processed in too short a time.

We hope in the future to find an opportunity to study a representative series of road accidents. Then we shall try to analyse the situations just before each accident in terms of their information processing demands and see if these are more important in subjects under the influence of alcohol.

A LABORATORY EXPERIMENT

Two parallel curved lines representing a road are generated on the display of a computer configuration (see Figure 2). Between these two lines there is a small circle which can be moved laterally by the subject by means of a steering wheel. Because the road and also the curve in it are continuously moving to the lower part of the display, the subject has the impression he is steering the circle to the upper part of the display on a road that unfolds itself in an unpredictable way.

The subject's task consists of holding the circle between two parallel lines by adapted steering movements. Every time the small circle touches or transgresses the limits of the road, it is registered by the computer. The latter also computes the time during which the circle is off the road.

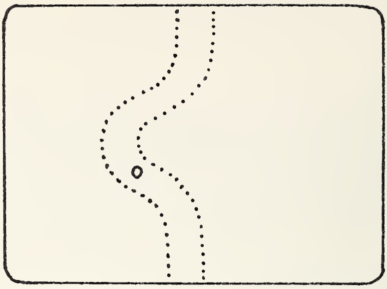


Figure 2 *Computer display showing curved parallel lines and small circle.*

The task lasts for 20 minutes. Within each minute it is relatively easy for 45 seconds, in which time there are a total of 15 to 18 curves to negotiate. The remaining 15 seconds within each minute form a 'critical period' during which the task varies from very easy (one curve per 15 seconds) to quite difficult (10 curves per 15 seconds). On the whole, there are 10 different critical periods, each of them appearing twice. The critical periods come in a random order, different for each subject. Each curve covers nearly half the height of the display. A curve appears only when the preceding one has disappeared completely. The concavity of the curve is to the left or to the right, in a random order.

It is clear that the described task has some face validity in connection with the problem of drinking and driving. Nevertheless, it must not be considered as simulating the complete driving task. The only resemblance is in the swift changes of direction after brief anticipation times that are required by the task. In other words, the resemblance consists in the episodes of information overload in which the required rate of decision making is quite high. We wanted to know whether such situations are more difficult to handle under the influence of small doses of alcohol.

Subjects and Experimental Design

We used three groups, each of 12 male university students. Their ages ranged from 18 to 28 years. The age distribution is given in Table II, which also shows the age distribution in each experimental condition.

The subjects were allocated at random to one of three experimental conditions which differed only by the quantity of alcohol given. We chose an experimental design with independent groups in order to be free of asymmetrical transfer effects described by Poulton (8).

The subjects were all tested before breakfast in order to have similar absorption curves, and at the same hour of the day, actually in the morning between 8 and 10 to control circadian influences on performance.

Before starting the experiment, the subjects were familiarized with the apparatus. They had ten minutes exercise during which no critical periods were present. Half an hour before starting the experiment they were served a drink which

TABLE II *Age Distribution of Subjects in the Three Experimental Conditions*

	Numbers of subjects of different ages										
Conditions	18	19	20	21	22	23	24	25	26	27	28
Placebo	3	2	1	3	3	–	–	–	–	–	–
Low dosage	2	–	3	4	1	–	–	1	–	–	1
'High' dosage	5	1	–	3	1	–	1	–	–	1	–

they were told contained a small dose of alcohol; a dose that would not yield a blood concentration too high to allow driving[4]. The subjects were also told that the aim of the experiment was to study low alcohol dosages as there was still some uncertainty as to their effects.

In the first or placebo condition, a drop of alcohol was spread on the surface of the drink so that subjects could smell it and have the impression of having received some alcohol. In the second condition, the low dosage condition, we wanted to reach a BAC of 25 mg/100 ml, and in the third condition, the 'high' dosage condition, where we wanted a dosage of 60 mg/100 ml, we used the Widmark's ratio to compute the alcohol quantity to be served. Immediately after having carried out the experimental task, the BAC was determined by measuring the alcohol concentration in the breath using a Photo-Electric Intoximeter[5] (6). In the placebo condition we obtained a mean value of 2 mg/100 ml; in the low dosage condition a value of 24 mg/100 ml with a standard deviation of 2.4 mg and in the high dosage condition a value of 57 mg/100 ml with a standard deviation of 5.5 milligrams.

RESULTS

We separately considered the number of errors and the duration of errors and we did so for non-critical periods and likewise for critical periods. In Figure 3 are shown the total number of errors and the total duration of errors made during the non-critical periods for each subject. Figure 4 shows the mean number of errors and their mean duration per critical period, also for each subject.

Of course, our hypothesis was that there should have been some deterioration of performance in the high dosage condition, when compared with the placebo condition. For the low dosage condition our hypothesis was rather in the direction of a higher performance in comparison to the placebo condition. We were indeed impressed by laboratory studies (4, 7, 10) which showed that small doses of alcohol sometimes enhance performance.

Statistical comparisons were carried out on the data presented in Figures 3 and 4. Analyses of variance, carried out although the F-ratios between some conditions amounted to significant values, did not show significant differences between conditions.

---

[4] In Belgium, people are not allowed to drive with BAC of 80 mg/100 ml or more. From 150 mg/100 ml on they are punishable and may be considered guilty without further proof in cases where they are involved in an accident. Presently the Government is considering a modification of the law in order to make driving with a BAC of 80 mg or over punishable as in other European countries.

[5] This apparatus is manufactured by Intoximeters Incorporated, Locust Street 1901, St. Louis, Mo. 63103.

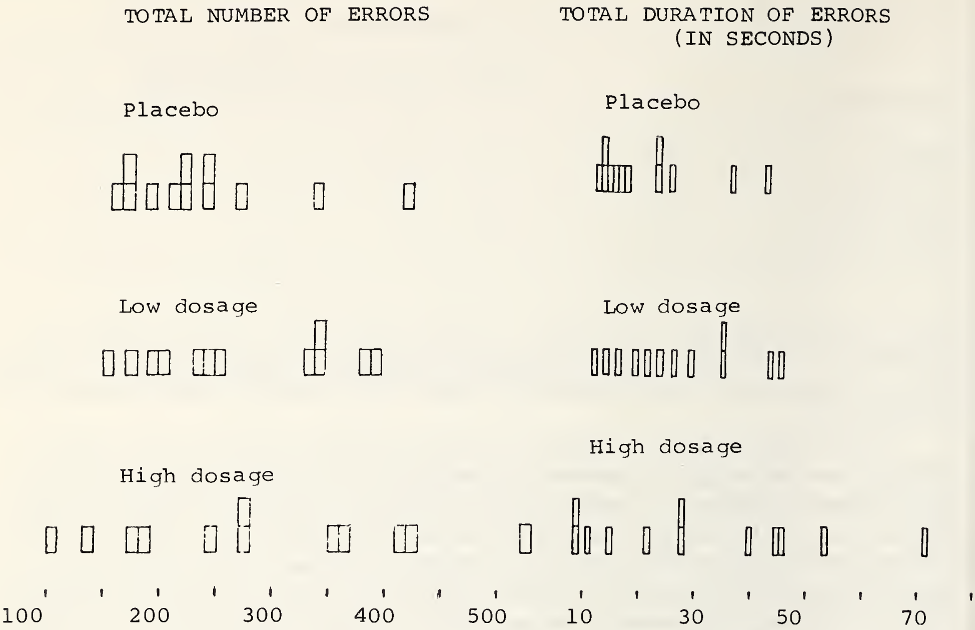


Figure 3 *Results during non critical periods.*

On the other hand, inspection of Figures 3 and 4 shows clearly that there are no differences between the numbers of errors in the different conditions, but that there is at least a strong tendency towards larger error duration scores in the high dosage condition, compared to the placebo condition, especially for the critical periods. Actually, a t-test between error duration scores from the placebo condition and from the high dosage condition for the critical periods, amounts to 2.085 which is significant at the 0.025 level (one-tailed test). The Mann-Whitney U-test yields a value of 41, which is significant at the 0.05 level (one-tailed test).

Consequently, we may conclude that there is at least a strong tendency to deterioration of performance in the information processing task used, by BACs between 50 and 60 mg/100 ml. In this experiment there was no enhancement of performance in the low dosage condition.

When we analyse the deterioration of performance in the high dosage condition we see that there is no difference in the frequencies with which the subjects in the three conditions go off the road, but the time during which they remain off the road increases in the high dosage condition. This seems to fit with the general idea that within the information processing system, the decision making or response choice subsystem deteriorates under the influence of alcohol. Because the direction of the curving 'road' on the computer display cannot always be anticipated, every subject makes some errors. However, correcting these errors requires an efficient choice of responses and this seems to become more difficult under the influence of alcohol. It must be stressed that this interpretation was formulated after the experiment.

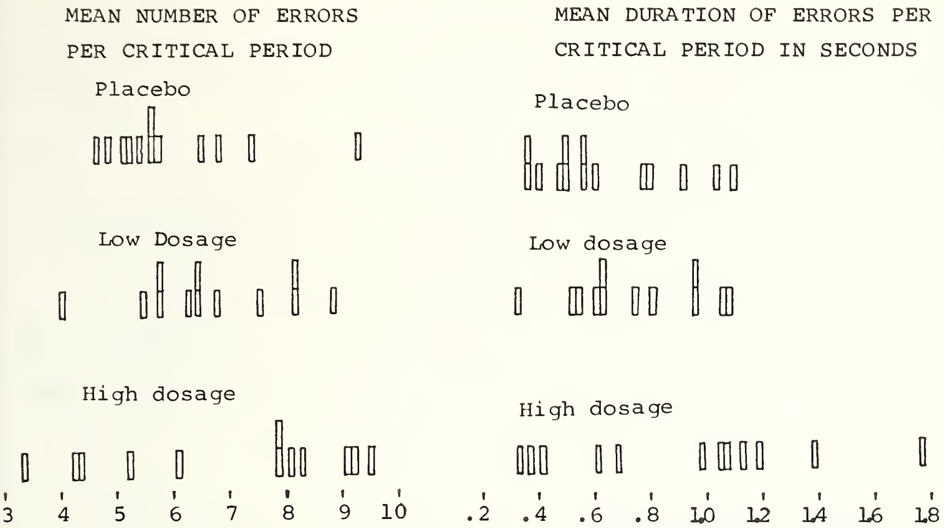


Figure 4 *Results during critical periods.*

Comments and Further Analysis of the Data

We further analysed our data in different ways. It must be pointed out that the following are to be considered only as a basis for new hypotheses.

As we already remarked, the dispersion of the scores varies in the different conditions. The F-ratios between high dosage and placebo conditions are significant for error-number and error-duration scores in both critical and non-critical periods. Between low dosage and placebo conditions the F-ratio does not attain the 0.05 level of significance except for the error number scores during non-critical periods.

The effect of alcohol on performance seems to vary greatly with the individual, at least when small doses are taken. This is, of course, a well known fact. In the study of Drew *et al* (3) for instance, ten subjects out of 40 made less tracking error under the influence of alcohol than when sober.

Within each condition we divided our subjects into two groups according to whether they obtained a score above or below the median value on an introversion-extraversion scale. The scale used was part of a Dutch personality questionnaire, constructed by Wilde (9) and largely inspired by the Maudsley Personality Inventory and the Two-Part Personality Measure of Heron. Analysing our data in this way, we did not find any difference in performance between extraverts and introverts under the influence of alcohol.

A similar analysis of our data was carried out after dividing our subjects into a group of younger and a group of older ones within each condition. Figures 5 and 6 shows the results. On inspection of these figures it seems clear that the performances of older subjects decrease from the placebo condition over the low dosage to the high dosage condition. On the other hand, the reactions of younger subjects do not change over the different conditions.

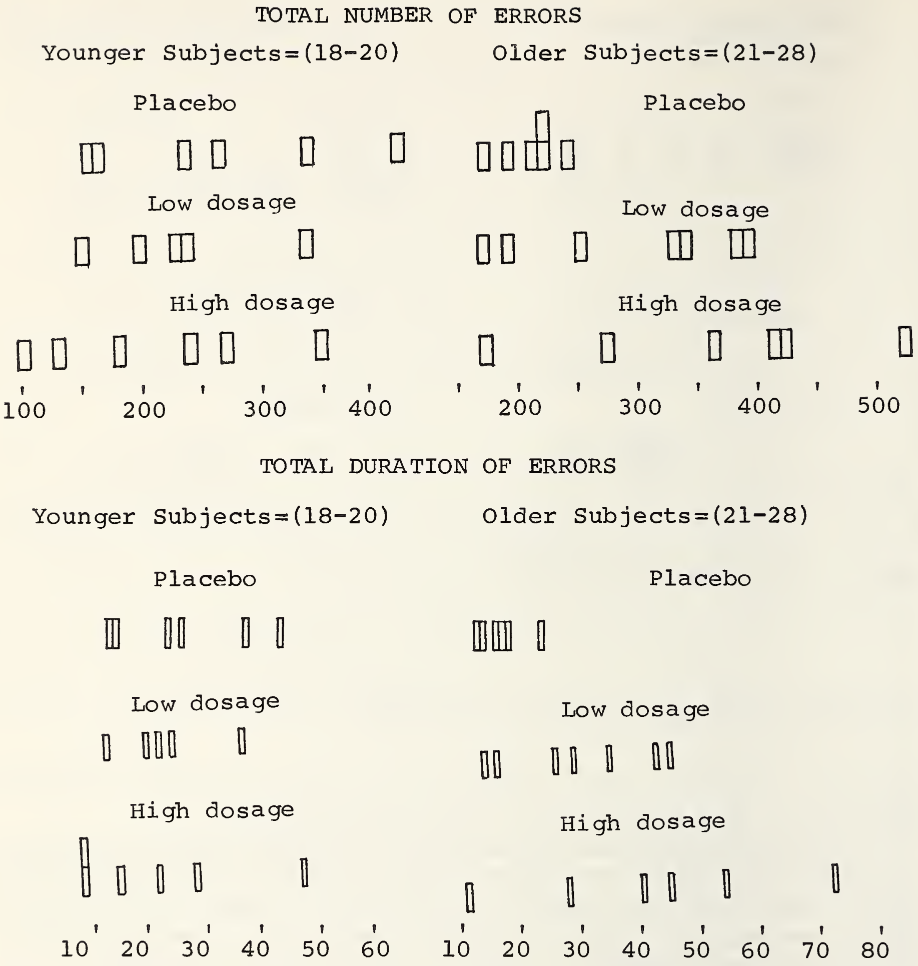


Figure 5 *Results of younger and older subjects during noncritical periods.*

For the older subjects the differences between the placebo conditions and the high dosage conditions are always significant at least at the 0.05 level (two-tailed tests), using t-tests as well as using Mann-Whitney U-tests. Differences between placebo and low dosage conditions are also significant in most cases and for our most sensitive performance measure, *i.e.*, the mean duration of errors during critical periods, even the 0.01 level is obtained (two-tailed t-test and Mann-Whitney U-test).

For the younger subjects there are no significant differences. One may wonder whether very young adults really are more difficult to influence by alcohol and also whether the low significance level we obtained in our experiment was brought about by their inclusion in our experimental groups.

CONCLUSION

The present laboratory study, corroborating by and large results obtained in previous studies, e.g. (3), seems to yield evidence that people under the influence of alcohol

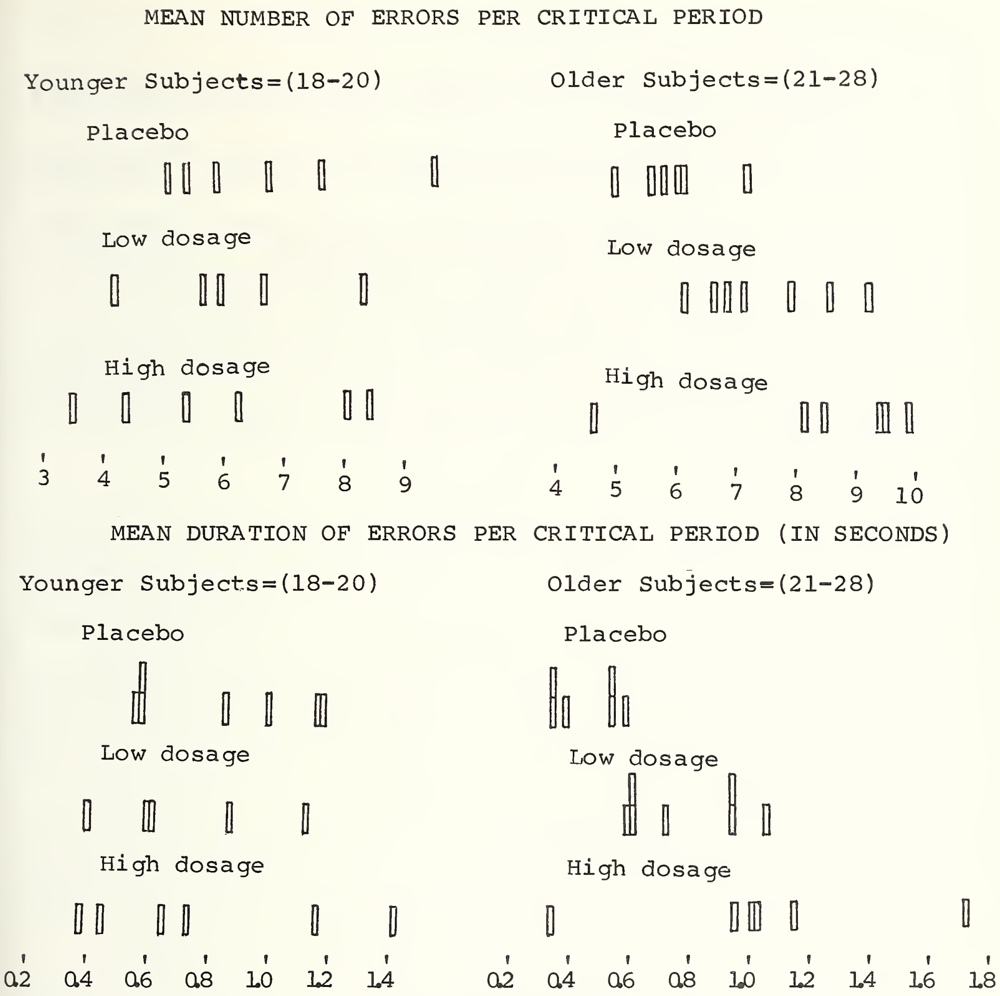


Figure 6 *Results of younger and older subjects during critical periods.*

doses of e.g., 60 mg/100 ml or even less, (25 mg/100 ml if we consider only the results from our older subjects), become slower in handling situations that require swift changes in their response choices. It seems further evident that some critical traffic situations require such quick decision making.

Finally, it must be remembered that perhaps even more important than decreased rate of decision making or response choice as cause of accidents, are emotional changes and the risk taking brought about by alcohol (2).

REFERENCES

1. Broadbent, D., *Decision and Stress.* Academic Press, London – New York, 1971.
2. Cohen, J., Dearnaley, E. J. and Hansel, C.E.M., The Risk Taken in Driving under the Influence of Alcohol, *British Medical Journal* 1, 1438 (1958).

3. Drew, G. C., Colquhoun, W. P. and Long, H. A., *Effect of Small Doses of Alcohol on a Skill Resembling Driving.* H.M.S.O., London, 1959.
4. Ettema, J. H. and Burer, E., *Alcohol en mentale belasting* (Alcohol and Mental Load), unpublished report of the Coronel Laboratory for Occupational Hygiene, University of Amsterdam, 1969 (in Dutch).
5. Fergenson, P. E., The Relationship between Information Processing and Driving Accident and Violation Record, *Human Factors* 13, 173 (1971).
6. Forrester, G. C. *Alcohol, Traffic Accidents and Chemical Test Evidence, Training Manual, The Photo-Electric Intoximeter.* Intoximeters Inc., St. Louis, 1970.
7. Hamilton, P. and Copeman, A. The Effect of Alcohol and Noise on Components of a Tracking and Monitoring Task, *British Journal of Psychology* 61, 149 (1970).
8. Poulton, E. C. *Environment and Human Efficiency.* C. C. Thomas, Springfield, 1971.
9. Wilde, G.J.S. *Neurotische labiliteit gemeten volgens de vragenlijstmethode.* Van Rossen, Amsterdam, 1963. (in Dutch).
10. Wilkinson, R. T. and Colquhoun, W. P., Interaction of Alcohol with Incentive and with Sleep Deprivation, *Journal of Experimental Psychology* 76, 623 (1968).

The Influence of Sex and Personality Factors upon the Effects of Tranquillizers on Driving Performance

A. B. Clayton,[1,2] T. A. Betts and P. G. Harvey

There is a growing literature on the effects of psychotropic drugs on driving behaviour, reflecting increased concern that such drugs may have a similar role to alcohol in contributing to the causation of road accidents. However, the problems associated with experiments using psychotropic drugs are many times more complex than similar research using alcohol.

Firstly, the task itself, driving a motor vehicle, involves a variety of cognitive, perceptual, and motor skills. Brown *et al* (3), for example, particularly distinguishes between control and decision skills and it is also known that failures in decision skills are of much greater importance in the causation of accidents than failures in control skills (4).

These skills may well be subserved by different cognitive or physiological structures, which, in turn, may be selectively responsive to certain drugs. Thus, the effects of drugs may be quite specific to certain skills rather than having global effects upon driving. Hence, it is of crucial importance that the components of the real-life driving situation being studied should be chosen appropriately.

Furthermore, individual differences such as sex and personality factors may lead to unique individual responses to a drug. Sex differences have been well documented in many fields. Human psychopharmacology is a notable exception. Most experiments in this field use all male subjects or unspecified mixed groups. However, there is no valid reason why there should not be marked sex differences in psychotropic drug responses.

Likewise, personality factors have been shown to influence performance in a wide range of experimental and real-life situation (7), but again they have received scant attention in the drugs and driving field, although a few studies have considered their interaction with alcohol (5).

---

[1] Senior Research Associate, Department of Transportation and Environmental Planning, P.O. Box 363, University of Birmingham, Edgbaston, Birmingham 15, England.

[2] The authors gratefully acknowledge the continued support of Professor J. Kolbuszewski, Department of Transportation and Environmental Planning, and Professor W. H. Trethowan, Department of Psychiatry, University of Birmingham. Financial assistance for the study was provided by G. D. Searle and Co. Ltd.

Obviously no single experiment can hope to unravel the many complexities that undoubtedly exist in this field. This paper describes an analysis of experimental data in an attempt to assess the influence of sex, certain personality factors and four psychotropic drugs on two actual driving tasks.

METHOD

The data for this paper were obtained from the results of an earlier study (1) and only that part of the method relevant to the present analysis will be given here.

Eighty subjects, mainly student volunteers, were randomly assigned to one of four groups, each of which contained 10 men and 10 women. In a double-blind crossover design, each subject was tested on two separate occasions, after having taken five doses of an active drug or an equivalent number of placebo tablets over the preceding 36 hour period. All normal ethical and medical precautions were observed.

The four drugs used and the dosages given (approximately equivalent to normal clinical doses) were as follows:

1) Chlordiazepoxide (Librium) – a benzodiazepine known to be an effective anxiolytic agent and very widely prescribed; 5 x 10 mg.

2) Amylobarbitone Sodium (Sodium Amytal) – a barbiturate which generally depresses the central nervous system and therefore which, like alcohol, in small doses may have a stimulant effect; 5 x 30 mg.

3) Trifluoperazine (Stelazine) – phenothiazine which has a neuroleptic action and possesses alerting as well as tranquillizing properties but with little or no sedative action in small doses; 5 x 2 mg.

4) Haloperidol (Serenace) – a butyrophenone which, in small doses, is now being used in the treatment of anxiety. It has a powerful anxiolytic effect with little or no sedative effects; 5 x 0.5 mg.

The two tasks, the data of which are analysed here, are described below. Both were carried out in an off-highway situation using a small saloon car (length 13 ft 0.6 ins (398 cm) and width 5 ft 1.8 ins (157 cm)) with a manual gearbox.

Weaving Task

The subject was required to drive a car four metres long in zigzag fashion along a line of six bollards spaced six metres apart and then reverse along the same path. The instructions were to complete the task as quickly as possible without hitting any of the bollards. Three runs were undertaken under each treatment condition. The task involved a large element of psychomotor skill in that accurate control of the steering wheel was required simultaneously with co-ordination of operation of the clutch and brake pedals. The scores obtained from the task were (a) total time taken and (b) number of bollards hit.

Gap Estimation Task

The subject was required to estimate, from a distance of 25 metres, the minimum gap required between two bollards to allow the car to be driven through without touching either bollard. Once the gap was measured, the subject then attempted to drive through it. The test was not timed. Five trials were undertaken under each treatment condition. The task was firstly a measure of the risk accepted by the subject and secondly a function of control skill in attempting to drive the car through the chosen gap. Two scores were obtained; (a) the estimated gap and (b) the success or failure in driving through gaps greater than the width of the car.

All subjects were allowed practice on each task. On each test occasion they were tested first sober and, secondly, about one hour after taking a dose of alcohol (0.5g/kg body weight) which produced a blood alcohol level of 50-55 mg./100 ml. Thus each subject completed a total of 12 trials on the weaving task and 20 trials on the gap estimation task.

The personality measure used was the Eysenck Personality Inventory Form A (8). It consists of a 57 item questionnaire requiring yes or no responses and provides scores on two basic personality dimensions, Extraversion-Introversion and Neuroticism–Stability. It has been widely used in England and norms for a variety of groups are available.

RESULTS

The main scores on each task, that is, the time taken to complete the weaving task and the gap estimates in the second task were approximately normally distributed and were analysed using the appropriate analysis of variance techniques. The results are given below.

The other scores, however, that is the numbers of bollards hit on the weaving task and the success or failure of driving through the gap were non-parametric and were analysed using chi-square. The results from these analyses suggested that there were no significant main drug effects or any sex or personality interactions with drug effects. Thus, any changes in the time taken on the weaving task were not accompanied by any significant changes in accuracy and, in the gap estimation task, the control skills required to drive through the gap successfully were likewise unaffected.

TABLE I *Mean Times on Weaving Task by Sex*

Drug Group		Mean time (sec) No Drug	 Drug	F-Ratio Drug x Sex
Amylobarbitone sodium	Male	50.29	51.29	$F_{(1,214)} = 3.89^{*}$
	Female	65.58	60.65	
Trifluoperazine	Male	48.17	44.79	$F_{(1,214)} = 9.77^{**}$
	Female	63.17	68.16	
Chlordiazepoxide	Male	38.47	41.18	$F_{(214,1)} = 1.72$
	Female	70.63	77.58	
Haloperidol	Male	40.12	39.60	$F_{(214,1)} = 5.99$
	Female	62.88	61.41	

* $p \lessdot .05$
** $p \lessdot .01$

Sex Differences

The data from the weaving task are shown in Table I. It should be noted firstly that for all drug groups there was a significant sex main effect with women tending to take longer to complete the task in every drug group. Significant drug x sex interactions were found for the amylobarbitone sodium and trifluoperazine groups although the direction of the changes after drug ingestion differed. Analyses of individual drug x sex groups suggested that, in several cases, the main drug effect for a particular sex was significantly different from zero. Thus increases in time taken were found for males in the chlordiazepoxide group and females in the trifluoperazine group and a decrease in time was found for males in the trifluoperazine group.

Data from the gap estimation task (Table II) suggested that there was a general overall trend for males to increase their estimation of the gap after drug ingestion whereas females tended to decrease their estimates. The only significant drug x sex interaction was for the chlordiazepoxide group although the following groups, males taking trifluoperazine and females taking haloperidol and chlordiazepoxide, all showed significant changes from zero effect in the directions of the overall trend. In all drug groups, there was a significant alcohol main effect in that, under alcohol, subjects tended to increase their estimates of the gap required.

TABLE II *Mean Scores on Gap Estimation Task by Sex*

Drug Group		Mean gap (in) No Drug	Mean gap (in) Drug	F-Ratio Drug x Sex
Amylobarbitone Sodium	Male	67.69	68.75	$F_{(1,374)} = 2.34$
	Female	66.51	66.60	
Trifluoperazine	Male	66.84	68.26	$F_{(1,374)} = 2.18$
	Female	68.88	68.68	
Chlordiazepoxide	Male	66.42	67.57	$F_{(1,374)} = 12.26^{***}$
	Female	70.46	68.44	
Haloperidol	Male	67.91	67.74	$F_{(1,374)} = 1.98$
	Female	67.87	66.18	

*** $p < 001$

Personality Measures

Within each drug group, the 20 subjects were divided into high and low Extraversion (E) scores and high and low Neuroticism (N) scores about the group medians. The mean E and N scores of each group are given in Table III.

TABLE III *Mean Personality Scores by Drug Group*

Drug Group	Extraversion High E	Extraversion Low E	Neuroticism High N	Neuroticism Low N
Amylobarbitone Sodium	12.9	8.2	13.0	5.9
Trifluoperazine	15.9	9.1	12.7	5.8
Chlordiazepoxide	15.8	9.9	14.4	8.1
Haloperidol	15.0	8.0	12.1	7.4

Extraversion/Introversion

The results for the weaving task are shown in Table IV. Significant drug x E score interactions were found for the amylobarbitone sodium, haloperidol, and trifluoperazine groups. For the first two of these groups, subjects with high E scores showed a decrease in time taken after drug ingestion whereas low E subjects showed a slight increase. For the trifluoperazine group, the changes were in the opposite direction with the subjects having high E scores showing an increase in time taken after drug ingestion.

TABLE IV *Mean Times on Weaving Task by E-Scores*

Drug Group		Mean Time (sec) No Drug	Drug	F-Ratio Drug x E-Scores
Amylobarbitone Sodium	High E	61.11	55.53	$F_{(1,214)} = 5.89$*
	Low E	54.76	56.42	
Trifluoperazine	High E	49.82	53.79	$F_{(1,214)} = 5.46$**
	Low E	61.53	59.17	
Chlordiazepoxide	High E	53.56	53.91	$F_{(1,214)} = 2.61$
	Low E	55.53	64.85	
Haloperidol	High E	51.32	47.40	$F_{(1,214)} = 6.69$*
	Low E	51.68	53.62	

* $p < .05$

For the gap estimation task, the trifluoperazine group again showed a significant drug x sex interaction with the high E subjects having a decrease in estimated gap after drug ingestion whereas the low E subjects showed an increase (Table V).

TABLE V *Mean Scores on Gap Estimation Task by E-Scores*

Drug Group		Mean gap (in) No Drug	Drug	F-Ratio Drugx E-Score
Amylobarbitone Sodium	High E	65.78	66.79	$F_{(374,1)} = 2.94$
	Low E	68.42	68.56	
Trifluoperazine	High E	68.43	66.31	$F_{(1,374)} = 26.12$***
	Low E	67.29	70.63	
Chlordiazepoxide	High E	67.09	67.09	$F_{(374,1)} = 1.11$
	Low E	69.80	68.92	
Haloperidol	High E	68.19	67.26	$F_{(374,1)} = 00$
	Low E	67.59	66.66	

*** $p < .001$

Neuroticism/Stability

The results for the weaving task (Table VI) suggested that there was a significant drug x N score interaction for the trifluoperazine group with subjects having high N scores showing an increase in time taken after drug ingestion whereas the low N subjects showed a decrease.

TABLE VI *Mean Times on Weaving Task by N-Scores*

Drug Group		Mean time (sec) No Drug	 Drug	F-Ratio Drug x N-Score
Amylobarbitone Sodium	High N	62.19	59.03	$F_{(214,1)} = 1.58$
	Low N	53.67	52.92	
Trifluoperazine	High N	50.78	54.26	$F_{(1,214)} = 3.91$*
	Low N	60.56	58.70	
Chlordiazepoxide	High N	58.75	65.67	$F_{(214,1)} = 1.79$
	Low N	50.34	53.09	
Haloperidol	High N	51.14	51.75	$F_{(1,214)} = 5.88$*
	Low N	51.86	49.27	

* $p < .05$

For the gap estimation task, there was some indication of an overall trend in that high N subjects tended to decrease the estimated gap after drug ingestion whereas low N subjects tended to increase it (Table VII). Significant drug x sex interactions showing this trend were found for the amylobarbitone sodium and trifluoperazine groups.

TABLE VII *Mean Scores on Gap Estimation Task by N-Scores*

Drug Group		Mean gap (in) No Drug	 Drug	F-Ratio Drug x N-Score
Amylobarbitone Sodium	High N	66.52	65.53	$F_{(1,374)} = 4.54$*
	Low N	67.67	69.82	
Trifluoperazine	High N	68.85	68.34	$F_{(1,374)} = 4.30$*
	Low N	66.86	68.61	
Chlordiazepoxide	High N	69.67	68.38	$F_{(1,374)} = 3.43$
	Low N	67.22	67.63	
Haloperidol	High N	68.80	66.98	$F_{(1,374)} = 2.70$
	Low N	66.98	66.94	

* $p < .05$

DISCUSSION

The results clearly demonstrate that interactions do occur between the drug used, the skill measured and the sex and personality of the drivers. The number of significant interactions obtained were far in excess of those expected on a chance basis. Such differences are to be expected in view of the comments made earlier.

In contrast, a blood alcohol level of approximately 50-55 mg/100 ml produced only one major effect. In the gap estimation task, this alcohol level increased the level of caution of the subjects in that their estimates of the gap required increased. The subjects were aware, of course, that they were taking alcohol and may thus have tended to overcompensate for its potential effects. However, there was no alcohol effect in the weaving task and, in both tasks, only one significant interaction, which may have been due to chance factors alone.

Regarding the drug effects, some of the sex differences may well be confounded with other factors, for example, driving experience. The main sex effect obtained in the weaving task is undoubtedly related to the lesser driving experience of women in terms of length of time of driving and number of miles driven. This trend was found both within the subjects used in this study and among the general population. However, this reason does not adequately explain all the data, particularly those relating to drug responses. In an unpublished study (9), it has been shown that Mandrax (methaqualone 250 mg – diphenhydramine 25 mg) and alcohol had markedly dissimilar effects in men and women. It is possible that this phenomenon is due, at least in part, to the known metabolic differences between men and women, but further knowledge about both these differences and the detailed pharmacology of drug metabolism is needed before any firm conclusions can be reached.

As regards personality differences, more potential explanations exist. In particular Eysenck's model of personality (6) makes a number of testable predictions as well as having a putative biological substrate. Basically, the two dimensions of Extraversion/Introversion and Neuroticism/Stability are considered to be orthogonal (that is, independent of each other). Eysenck has suggested that the biological structures subserving these dimensions are the reticular formation of the limbic system, thus involving the concept of cortical arousal. While it may be argued that this model of personality is only partially adequate, it has provided much experimental data and theoretical speculation (6,7).

On the weaving task, three of the four drugs showed significant interactions with Extraversion scores, although not all were in the same direction, whereas, on the gap estimation task, only one interaction was found. With the Neuroticism scores, there were fewer interactions for both tasks. It should be noted that the same trend in gap estimation was shown by both high N scorers and women. Although there were more females than males in the high N group, sex differences alone cannot totally explain the interaction with Neuroticism. An analysis of sex x Neuroticism was not possible because of the small size of the sample. In the gap estimation task, the high N scorers became less cautious whereas the low N scorers became more cautious. This difference would tend to suggest that the effects of the drugs were to reduce the anxiety levels of the high N group and merely to sedate the low N group.

Generally, however, these results are difficult to reconcile with predictions based upon a simple arousal model. Other work has also been found to be incompatible with this model and, hence, more complex models have been proposed. Broadbent (2), for instance, has postulated a two arousal system which might provide a better explanation of these data, although such explanations are *post hoc* and thus limited. Furthermore, the relative lack of knowledge that exists regarding the precise mode and site of action of these drugs in the intact human brain, limits the explanatory power of such models.

In this experiment, normal subjects, unselected for extreme E and N scores, were used. Thus, it cannot be said that they are directly comparable to a clinical population. For good ethical and practical reasons, we believe that it is impossible to undertake a well-designed and experimentally rigorous study using patients. However, it is considered that some cautious extrapolation from the present results to the clinical population is justifiable, because it has been demonstrated that significant interactions exist between personality measures and drug effects. But before further generalisations can be made, it is necessary to consider extreme E and N scoring subjects as it tends to be they who represent an at-risk population.

Finally, it should be emphasized that the results are task-specific. Within the tasks used there was a tendency for significant drug interaction effects to occur only with the higher decision skills rather than with the simpler control skills. In the real-life driving situation, it is these decision skills that are the most important components of the task, and thus any reduction in performance will be potentially hazardous.

CONCLUSIONS

It has already been shown that these drugs have an effect upon performance on low-speed vehicle-handling tests (1). This further analysis has strongly suggested that these effects are markedly dependent upon several independent variables including the nature of the task and, in particular, the sex and personality of the subjects.

Giving rational advice to drivers or Governments about the effects of prescribed psychotropic drugs upon driving performance requires precise knowledge of the influence of these factors. It is disappointing that so few studies to date have investigated them.

REFERENCES

1. Betts, T. A., Clayton, A. B. and Mackay, G. M., Effects of Four Commonly-used Transquillizers on Low-Speed Driving Performance Tests. *British Medical Journal*, 4, 580 (1972).
2. Broadbent, D. E., *Decision and Stress.* Academic Press, London, England, 1971.
3. Brown, I. D., Tickner, A. H. and Simmonds, D.C.V. Interference between Concurrent Tasks of Driving and Telephoning, *Journal of Applied Psychology* 53, 419 (1969).
4. Clayton, A. B., An Accident-based Analysis of Road User Errors, *Journal of Safety Research* 4, 69 (1972).
5. Drew, G. C., Colquhoun, W. P. and Long, H. A. Effect of Small Doses of Alcohol on a Skill Resembling Driving, *British Medical Journal* 2, 993 (1958).
6. Eysenck, H. J., *The Biological Basis of Personality*, C. C. Thomas, Springfield, Illinois, 1967.
7. Eysenck, H. J., *Readings in Extraversion-Introversion Vol. 3 Bearings on Basic Psychological Processes.* Staples Press, London, England, 1971.
8. Eysenck, H. J. and Eysenck, S.B.G. *Manual of the Eysenck Personality Inventory*, University of London Press, London, England, 1964.
9. Swaby, M., *A Study of the Interaction between Mandrax and Alcohol.* Unpublished M.Sc. Dissertation, University of Birmingham, England, 1973.

The Combined Effects of Alcohol and Common Psychoactive Drugs: I. Studies on Human Pursuit Tracking Capability

R. Burford, I. W. French[1,2] and A. E. LeBlanc

The use of more than one drug at a time has become increasingly common as more and more drugs are available and their usage increases. The most commonly used drug in North America and much of the rest of the world is alcohol. It is probably fair therefore to say that the drug most commonly consumed in conjunction with other drugs is ethanol.

The study of drug interactions has taken many forms (1, 9). Some studies have emphasized the development of pharmacokinetic understanding of drug interactions, *i.e.,* how one drug affects the absorption, distribution and metabolism of the other. Less commonly, at least in the psychoactive drug field, attempts have been made to develop an understanding of the pharmacodynamic interactions, *i.e.,* how one drug affects the way the second drug produces its biological actions (5).

The most common approach, however, is a descriptive approach in which the resultant effects of the pharmacodynamic and pharmacokinetic are measured without any attempt being made to parcel out the mechanisms by which the effects were achieved (7). Our research belongs to this approach. Though provision was made in the experimental design for insights to be gained in the mechanistic area, no attempts will be made to analyze the results. Moreover, since the terminology of drug interactions is so confused and difficult to apply we will not use it. The measures looked at are reported only with respect to their direction and size, in relation to those produced by blood ethanol levels alone of and around 0.06g/100 ml. No conclusions as to the nature of the interaction are presented.

Although a descriptive approach may seem simple, it presents some dilemmas. To completely describe the drug interaction one should examine all doses of each drug with all doses of the second drug for a range of drug effects (7). This is necessary since one cannot conclude that the nature of the interaction will be the same at all dosage combinations. The drug ranges in this study are limited in the case of ethanol to those

---

[1] Nucro-Technics Laboratories, 2000 Ellesmere Rd., Scarborough, Ontario, Canada.

[2] This research was funded by the Insurance Bureau of Canada. The authors would like to thank the National Research Council for the use of the Stressalyzer, Dr. L. Buck of the National Research Council for his assistance in the data analysis, Dr. A. Mildon of the Banting Institute, University of Toronto for her medical assistance and Dr. A. B. Morrison of the Health Protection Branch Health and Welfare, Canada, Ottawa for his co-operation in providing the marihuana for the research project.

doses which would yield blood levels below that taken by the courts to be presumptive evidence of impairment (0.08g/100 ml in Canada).

The doses of the drugs given were chosen to be reasonable therapeutic doses of the counter drugs or prescription drugs. In the case of marihuana the dose was taken as that used recreationally.

Drugs have a variety of effects. For any of these effects a legitimate study of interactions could be undertaken. In these experiments we did not examine the therapeutic effects of the various medications. Rather we emphasized the drug effects that might lead to automobile driving impairment. The problem that must still be settled is which components of driving should be examined. For this experiment we used a test apparatus developed by the National Research Council of Canada as a pursuit-tracking device capable of measuring behaviours relevant to driving (2, 3). The intent of this study was to examine the interaction of alcohol and drugs which have a wide use. The drugs studied were diazepam, a minor tranquillizer; phenobarbital, a sedative; diphenhydramine, an antihistamine, codeine (as ACC), a mild analgesic; and marihuana, an hallucinogen.

METHODS

The Stressalyzer

The Stressalyzer (2, 3) is a pursuit-tracking device capable of detecting subtle differences in psychomotor skill as a result of the effects of psychoactive drugs. The subject being tested is required to align the cross-hairs of a pointer, by appropriate movement of an aircraft-type steering wheel, over a lighted target for a period of 200 millisec before the next target is presented. There are five possible targets arranged equidistant through 30° of arc and they are randomly presented 100 times during any one run. The Stressalyzer measures the following parameters of psychomotor skill: error rate, error correction time, target acquisition time, overshoot rate, settling time and total response time. Certain of these parameters are analyzed with respect to target position, *i.e.,* in terms of response probability. Only data on total response time are reported here as detailed statistical analysis of other parameters is not yet completed.

Subjective Impairment Rating

The subjects were asked as part of a mood assessment scale, to rate their impairment. The scale ran from 0 to 20 with a score of 10 as the normal party level of intoxication.

Drug Analyses

Blood alcohol was measured using a gas chromatographic (GLC) method (6) on blood samples taken from the finger tip. Diphenhydramine (11) and phenobarbital (8) blood levels were determined by modifications of published methods using a flame ionization equipped GLC after extraction from plasma obtained by venipuncture. Diazepam (4) was analyzed after extraction from plasma by GLC with a Ni-63 electron capture detector. All methods included the use of an internal standard added prior to extraction. In the case of codeine, which was administered as aspirin, caffeine, codeine combination, the blood salicylate (10) levels were assayed by a fluorometric method as an indirect way of assuring drug administration and absorption.

Drugs

The alcohol used was commercially available vodka diluted with orange juice. The drugs were commercially available preparations. The placebo in the case of alcohol was just the orange juice. For the drugs, drug-free equivalent preparations were given.

The marihuana (1.1% tetrahydrocannabinol by weight) used in this study was supplied by the Health Protection Branch (Health and Welfare, Canada). Tetrahydrocannabinol-free marihuana was used as placebo. The marihuana was rolled into 0.5 g cigarettes.

A total dose of 0.80 g/kg of ethanol was administered during any alcohol trial. A total dose of 50 mg of diphenhydramine, 5.0 mg of diazepam, 32 mg of phenobarbital, 30 mg of codeine (as ACC) and 2 g of marihuana was given for the respective drug interaction trials.

Subjects

The subjects were healthy males, age 18 to 30. Their body weight varied from 57.6 to 88.6 kg (mean = 71.4kg). The subjects were drug-free at the time of the experiment. This was verified by urine screening. The subjects used for the marihuana studies, although drug-free at the time of the study, admitted to regular (several times a month for the preceding six months) use of marihuana. There were eight subjects in each of the first two phases and five in the third phase.

Experimental Design

All subjects, after familiarization with the Stressalyzer apparatus, were given placebo, alcohol, and alcohol plus drug trials in a random order. For the first series the test conditions were placebo, alcohol, alcohol plus diphenhydramine and alcohol plus diazepam. The second series had placebo, alcohol, alcohol plus phenobarbital and alcohol plus ACC conditions. For the third series, placebo-marihuana and alcohol, and alcohol plus active marihuana conditions were tested.

The subjects fasted overnight and appeared at the laboratory in the morning. They were given a standard light breakfast. One hour later they began the schedule. At zero time the first beverage was provided. It was consumed steadily during the first hour. If it was the alcohol condition, it contained 0.60 g/kg total dose in orange juice; if placebo, then an equivalent volume of orange juice. At time periods 90 and 150 minutes, additional volumes of orange juice or orange juice plus vodka were provided. The alcohol dose was 0.10 g/kg each time.

Blood samples for alcohol, diphenhydramine, diazepam and phenobarbital were taken at 0, 60, 90, 120, 150, 180, 240, 300 and 360 minutes. Stressalyzer tests and mood scale checklists were administered at the same time.

In the case of all drugs except marihuana, the drug or its placebo was administered at zero time. In the case of marihuana, three joints were smoked at 90 minutes while consuming the first alcohol maintenance dose and the fourth at 150 minutes. Pulse rate was monitored to verify that the subjects were effectively consuming their marihuana.

During the times that the subjects were not being tested they remained in a living room setting.

RESULTS

A typical time course of the blood alcohol is given in Figure 1. The blood level rose during the early period to 0.06 g/100 ml and was maintained there for two hours. The other series were similar with the plateaus deviating by less than 0.01 g/100 ml.

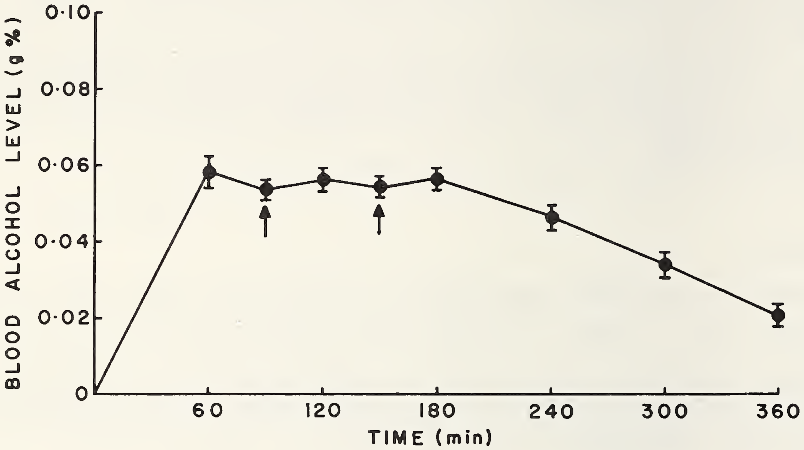


Figure 1 *Time course of blood alcohol levels. Arrows indicate times at which the maintenance doses were given.*

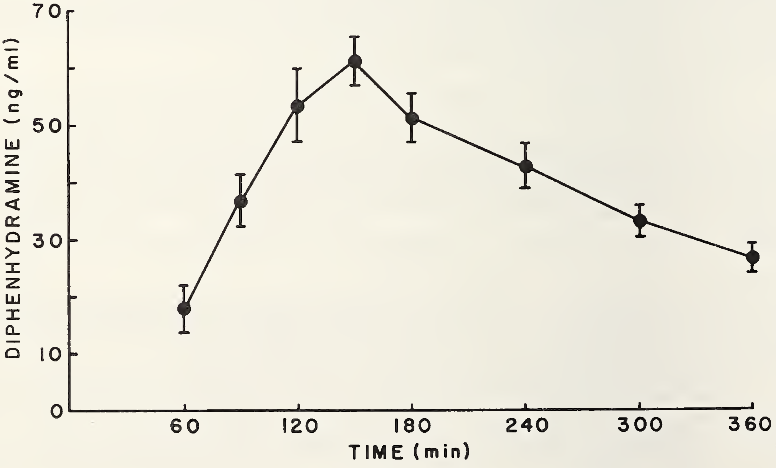


Figure 2 *Time course of diphenhydramine concentrations in plasma.*

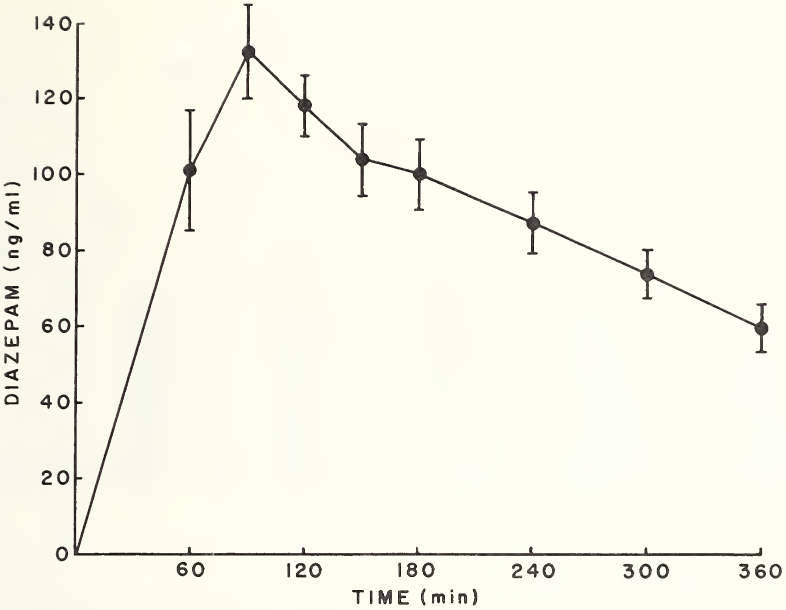


Figure 3 *Time course of diazepam blood levels.*

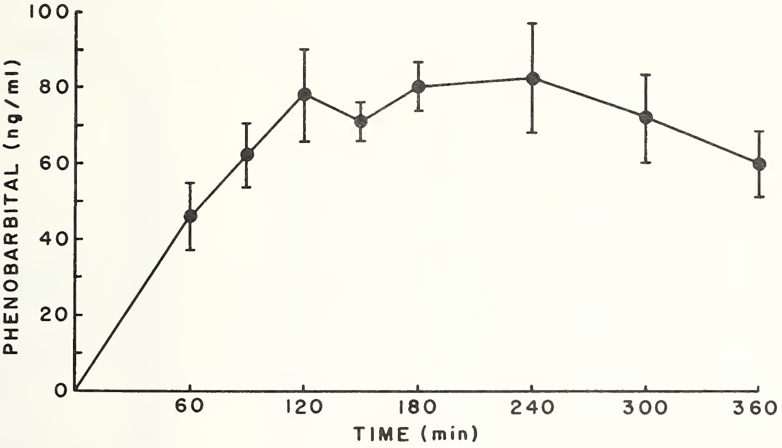


Figure 4 *Time course of phenobarbital blood levels.*

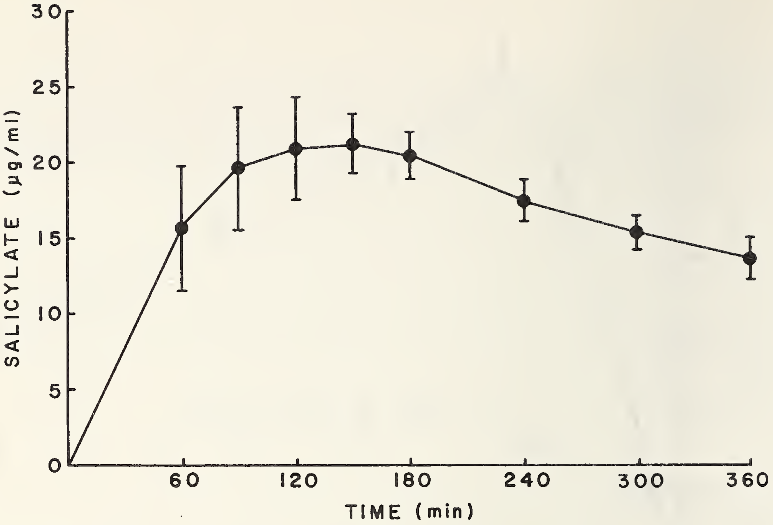


Figure 5 *Time course of salicylate levels.*

Figures 2-5 give the drug concentrations over time for diphenhydramine, diazepam, phenobarbital and salicylate (and therefore presumably codeine). It is clear that their peak levels occurred during the stable alcohol phase.

The maximum heart rate changes also occurred during this phase. The measurement of pulse rate indicated a degree of change (about a 25% increase) that corresponds to that seen with social cannabis use. The subjective impairment scales (Figure 6-8) also showed that the peak impairment occurred during this phase. Although a variety of indices of Stressalyzer performance could be examined, only one index is analyzed here. Figure 9 shows the maximum percentage increase of total response time compared to pacebo.

DISCUSSION

The alcohol blood data indicate that the regimen chosen was effective in producing a moderate blood alcohol level. This level was maintained for a period of two hours by supplemental consumption of additional alcohol. This level and pattern of maintaining is highly relevant to the very common moderate consumption of alcoholic beverages. Moreover, the measures taken for all drugs indicated that the peak drug effects coincided with the peak alcohol effects.

The subjective effect measures were interesting. They showed uniformly a predictable tracking of the drug levels. However, in the case of diazepam no important difference in subjective impairment was produced by its addition to alcohol. In the case of diphenhydramine, there were no differences seen between alcohol alone and alcohol plus drug, until later time periods. Yet in both cases there was significant objective impairment.

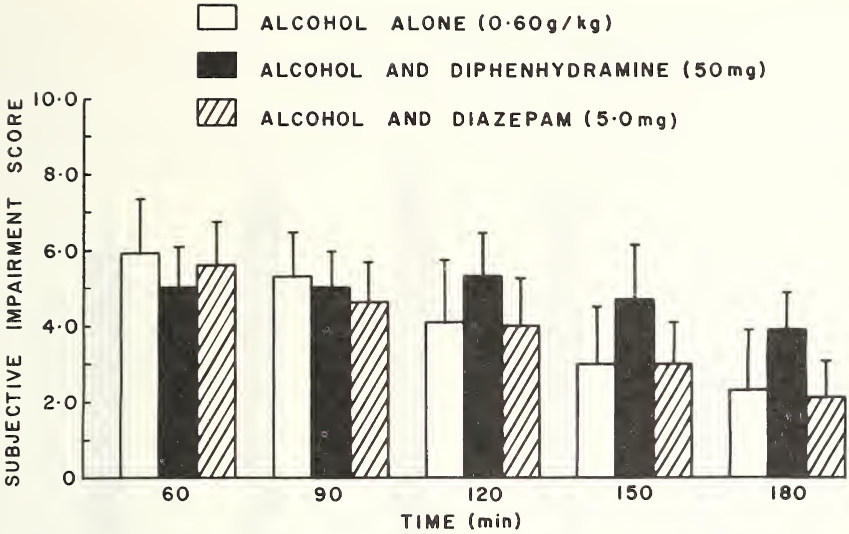


Figure 6 *Subjective impairment scores over time under alcohol, alcohol and diphenhydramine, and alcohol and diazepam.*

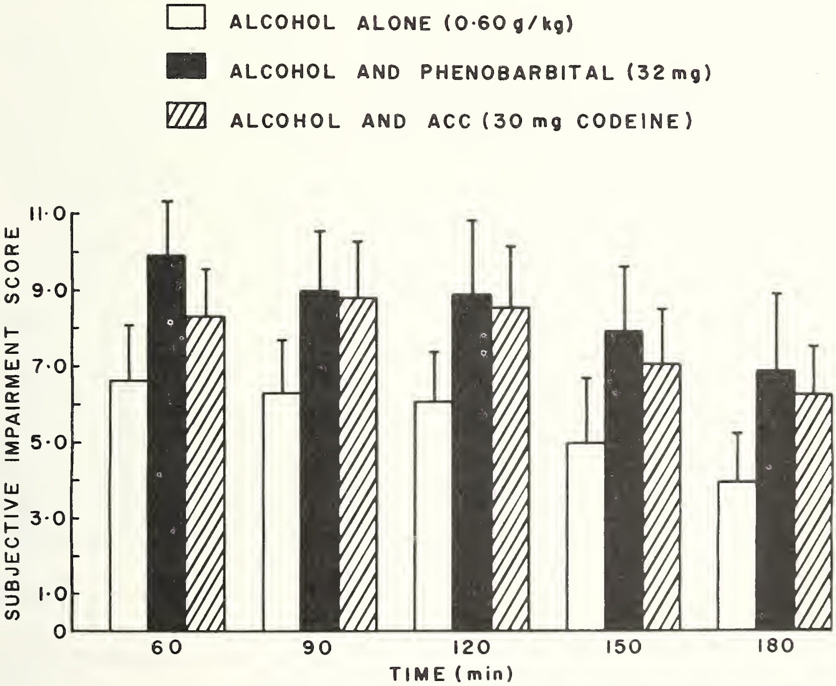


Figure 7 *Subjective impairment scores over time under alcohol, alcohol and phenobarbital, and alcohol and codeine (ACC).*

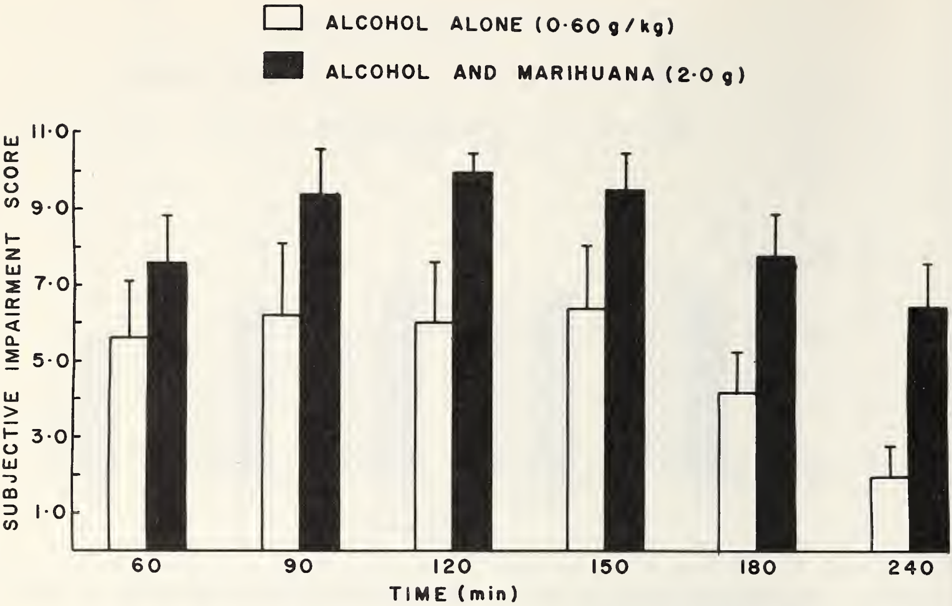


Figure 8 *Subjective impairment scores over time under alcohol, and alcohol and marihuana.*

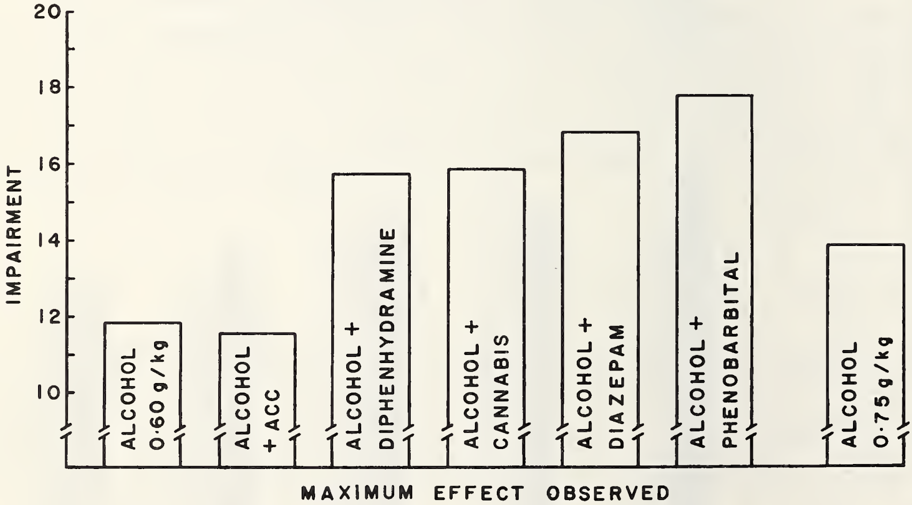


Figure 9 *Maximum percentage increase of total response time compared to placebo on the Stressalyzer for the different drug conditions. The bar to the extreme left indicates impairment produced by a 0.06 g/100 ml blood ethanol level and the bar at the extreme right indicates impairment produced by a 0.10 g/100 ml blood ethanol level. The rest of the bars indicate impairment produced by the lower dose of ethanol (0.06 g/100 ml) plus the drug indicated.*

Phenobarbital and codeine (ACC) produced consistent increases of perceived impairment at all time periods examined. However, the objective measure of impairment revealed that though the phenobarbital did produce meaningful impairment, the codeine did not. In the case of marihuana, the subjects reported the greatest augmentation of perceived impairment. Though there was meaningful impairment, the impairment was not the largest measured.

CONCLUSIONS

These data indicate that at blood levels of ethanol below that taken by the law as presumptive evidence of impairment, meaningful additional impairment (about the amount that 0.08 g/100 ml alcohol alone would produce) can be produced by the simultaneous use of moderate doses of a range of widely used drugs. It is particularly important to emphasize that these impairments did not conform to the subjective assessments of impairment and therefore presumably risk.

These levels of impairment are clear threats to automotive safety. Greater attempts must be made to inform the public and government agencies, not so much that drug interactions exist, but that meaningful interactions occur at such low levels of pharmacological intervention.

REFERENCES

1. Barnes, T. H., *Interaction of Alcohol and Other Drugs*, Suppl. 1, Addictions Research Foundation, Toronto, 1973.
2. Buck, L., *Performance Data for the NRC Stressalyzer*. Report of the National Research Council, Division of Mechanical Engineering. LTR-CS-69, Ottawa, 1972.
3. Buck, L., Hyde, F., and Leonardo, R., *Operating and Statistical Procedures for the NRC Stressalyzer MK6*. Report of the National Research Council, Division of Mechanical Engineering. LTR-CS-93, Ottawa, 1972.
4. De Silva, J.A.F. and Puglisi, C. V., Determination of Medazepam (Nobrium), Diazepam (Valium) and their Major Biotransformation Products in Blood and Urine by Electron Capture Gas-Liquid Chromatography. *Analytical Chemistry* 42, 1725 (1970).
5. Hartshorn, E. A., *Handbook of Drug Interactions Pt. I.* Donald E. Franche, Cincinatti, Ohio, 1970.
6. Le Blanc, A. E., Microdetermination of Alcohol in Blood by Gas-Liquid Chromatography. *Canadian J. Physiology and Pharmacology* 46, 665 (1968).
7. Loewe, S., *The Problem of Synergism and Antagonism of Combined Drugs.* Arzneimittel-Forschung 3, 285 (1953).
8. MacGee, J., Rapid Identification and Quantitative Determination of Barbiturates and Glutethimide in Blood by Gas-Liquid Chromatography. *Clinical Chemistry* 17, 587 (1971).
9. Polacseck, E., Barnes, T., Turner, N., Hall, R. and Weise, C., *Interaction of Alcohol and Other Drugs. An Annotated Bibliography.* Addictions Research Foundation, Toronto, 1972.
10. Saltzman, A., Fluorophotometric Method for the Estimation of Salicylate in Blood. *J. Biological Chemistry* 174, 399 (1948).
11. Wolen, R. L. and Gruber, C. M. Jr., Determination of Propoxyphene in Human Plasma by Gas Chromatography, *Analytical Chemistry* 40, 1243 (1968).

The Combined Effects of Alcohol and Common Psychoactive Drugs: II. Field Studies with an Instrumented Automobile

A, Smiley[1,2,], A. E. LeBlanc, I. W. French, and R. Burford

While much research has been done on the effects of alcohol and other drugs on performance in driving simulators or on tasks requiring skills related to driving (2, 3, 4), very little work has been done on the effects of these drugs on performance while driving a real car. The following paper describes such a study and the preliminary results from the analysis. A more extensive report will be published at a later date.

The intention behind the experiment was simply to describe the changes in driver behaviour under various drug conditions. No attempt will be made to establish the relation between the pharmacology of the drug and the physical effects it has on driving.

The drug conditions which were examined were as follows: placebo, alcohol at the 0.06% level, alcohol at the 0.06% level in combination with diphenhydramine (an antihistamine), alcohol at the 0.06% level in combination with diazepam (a minor tranquillizer) and alcohol at the 0.06% level in combination with marihuana.

METHOD

Subjects

Eight subjects, six male and two female, ranging in age from 19 - 27, participated in the experiments. All subjects had used both alcohol and marihuana previously and reported having experienced a high on marihuana. All were accustomed to driving an automatic car periodically and had at least two years driving experience.

Site

The site used for the experiment was an 8.5 mile stretch of the new highway 417, in the Province of Ontario, which was not open to the public at the time of the experiment.

---

[1] National Research Council, Ottawa, Canada, K1A 0S2.

[2] The authors would like to thank the National Research Council for the use of the automobiles and support personnel, Dr. M. Beach, Ottawa for his medical assistance and Dr. A. B. Morrison of the Health Protection Branch, Health and Welfare, Canada, Ottawa for his co-operation in providing the marihuana for the research project. The authors also thank the CTV Network for their co-operation and assistance in organizing and filming the study.

Equipment

A large sedan-type, late model American car, instrumented to measure various driving parameters, was driven by the subject. It is described in detail by Sewell (5). The instrumentation included a potentiometer attached to the steering wheel to measure steering wheel position, a wheel counter operated by a light-interrupting mechanism in the right rear wheel to measure distance, a real time clock, a secondary task peripheral light situated on the dash of the car and extinguished by means of a foot pedal. Analogue data were converted to digital form by an A/D converter and then stored along with other digital data in a mini computer located in the trunk. A buffering system was used to allow data to be stored in the computer while date collected previously were transferred to tape on a tape recorder also in the trunk.

Two other cars were used to act as opposing traffic in order to increase the realism of the driving task. Radio connections between the middle and one end of the track and the subject's car enabled an experimenter in the back seat of the car to start the opposing cars at the appropriate times.

Five hundred, eighteen inch pylons were used to set up a slalom course half a mile in length. The narrowest gap the subjects were required to drive through was eight feet in width. The pylon course occurred midway along the 8.5 mile test site (see Figure 1).

Three traffic lights were installed, fifty feet apart, at one end of the test stretch. Cables across the lane at a distance of one hundred and fifty feet from each traffic light were connected to the lights. The weight of the car tires passing over the cables activated one of the three signals. The subjects were asked to stop at a white line adjacent to the traffic signal which was on.

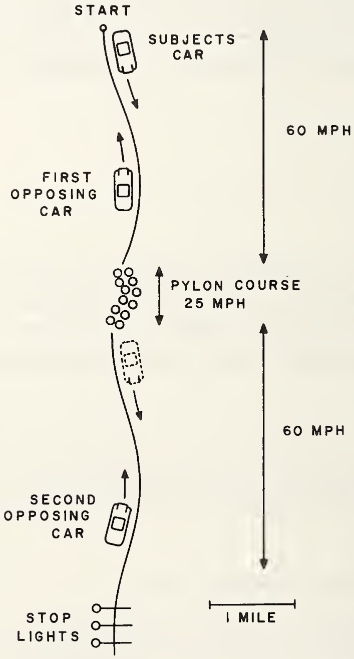


Figure 1 *Driving Course.*

Procedure: Administration of Drugs

The schedule by which the subjects were administered drugs allowed a run in the instrumented car to take place every half hour. Each subject made one run under one of the drug conditions each day.

Body weight was used to determine the amount of alcohol needed to bring the subject up to a 0.06% level. The alcohol was consumed in three drinks over a half hour period with a full hour elapsing after the consumption of the alcohol before driving began. For the placebo condition the subject consumed three drinks of orange juice only, over the same time period. A pill containing either sugar, or 50 mg of diphenhydramine or 5 mg of diazepam was administered 90 minutes before the driving test. Three 0.5 g joints of marihuana (the placebo having the active ingredient THC removed) were smoked over a 30 minute period, 30 minutes before the driving test.

The design of the experiment was a Latin square so that practice effects would be balanced over all the drug conditions.

Procedure: Driving Task

The subjects entered the car at the start point (Figure 1) and adjusted the seat position and safety belt. An experimenter in the back seat then gave the subject instructions to put the reaction time light out as soon as it appeared by pushing a foot pedal to the left of the brake. The light appeared, on the average, once every twelve seconds, during the run. Subjects were then asked to drive at 60 mph for approximately three miles. Just before the cone course the subject was asked to slow down to 25 mph and keep the car as close to 25 mph as possible throughout the slalom course[3]. (The cones knocked over were counted and placed back in their original positions before the next run.) The subject then took the car up to 60 mph for another 3½ miles. At 300 yards from the traffic signals a sign instructed the driver to slow down to 30 mph. The subject was told to stop at the traffic signal which was on, with the front wheels touching the white line adjacent to the signal. The distance of the front wheels from the white line was then measured and recorded. The subject then made a U turn at a distance of several hundred yards from the stoplight. The driving task was then repeated, in the reverse order, another stop being made from a speed of 30 mph at the traffic light that was on before proceeding at 60 mph. At the start of each 60 mph section, the experimenter in the back seat of the subject's car radioed requests for an opposing car to start from the other end of the section towards the subject.

On the day preceding the experiment each subject made four trial runs through the slalom course to avoid large practice effects over the five-day period of the experiment. This also allowed subjects to become familiar with driving the instrumented vehicle.

Measurements Taken

The following measures of driver performance were made: steering amplitude and frequency in the 60 mph region, steering amplitude in the 25 mph region, speed and speed variation in both the 60 and 25 mph zones, reaction time to the peripheral light on the dash, number of pylons knocked down, distance between the front tires and the white line adjacent to the traffic signal.

[3] The combination of low speed and violent movements in the cone course caused the computer to lose power on almost half the runs. When this occurred, data for the remainder of the course were not recorded and the computer had to be restarted at the end of the course.

RESULTS

Due to the preliminary nature of this report the results of the analysis will be discussed briefly with little interpretation being given.

Speed

Though the subjects were asked to maintain 60 mph, the average speed they did maintain was dependent on the drug condition. Subjects on the placebo drove at a significantly higher speed than under any other condition (levels of significance ranging from 0.10 to 0.01). On alcohol alone, the subjects drove at a significantly higher speed (0.05 level of significance) than on alcohol with diazepam or on alcohol with marihuana. The slowest average speeds recorded were for subjects on alcohol and marihuana. In summary, the drug conditions in order of decreasing mean speed were placebo, alcohol, alcohol with diphenhydramine, alcohol with diazepam and alcohol with marihuana.

It is possible that the subjects were slowing down in response to the degree of impairment they felt. The fact that subjects in the Stressalyzer experiment (see Burford, French and LeBlanc, preceding paper) expressed stronger feelings of impairment on alcohol and marihuana than under any other condition lends some support to this interpretation.

No clear trends between drug conditions were observed for speed variation.

Steering Movement

The measure of steering movement used in the 60 mph region was a power spectral density function of steering wheel angle. This function gives a measure of the power or amplitude in the signal (steering wheel angle over time) for each frequency level. For each subject and drug condition a power spectral density function was calculated. The area under the curve gives a measure of the average amplitude of steering wheel movements. One subject's results are shown in Figure 2 with the size of the area shown under each curve. As can be seen, this subject made the largest amplitude movements under the alcohol and diphenhydramine condition and the lowest under the alcohol and diazepam condition. Where any two power spectral functions in Figure 2 are separate horizontally, e.g., placebo, and alcohol and diphenhydramine, this indicates that there were significant differences (at 0.10 level or greater) for all subjects between these two conditions. The drug conditions in order of decreasing mean area were alcohol and marihuana, alcohol and diphenhydramine, alcohol, placebo, and alcohol and diazepam.

The fact that the average amplitude of steering movements for the placebo is not the smallest or the largest may indicate that there is an optimum amount of control. As both under and oversteering can produce poor tracking performance the placebo condition may here represent the optimum point where an adequate level of tracking performance is maintained for a minimum average steering amplitude. However, an actual measure of tracking performance would be needed to verify this.

Secondary Task Light

Reaction time to the secondary task light under the alcohol condition was significantly faster than for the placebo or for the alcohol and marihuana condition (at the 0.01

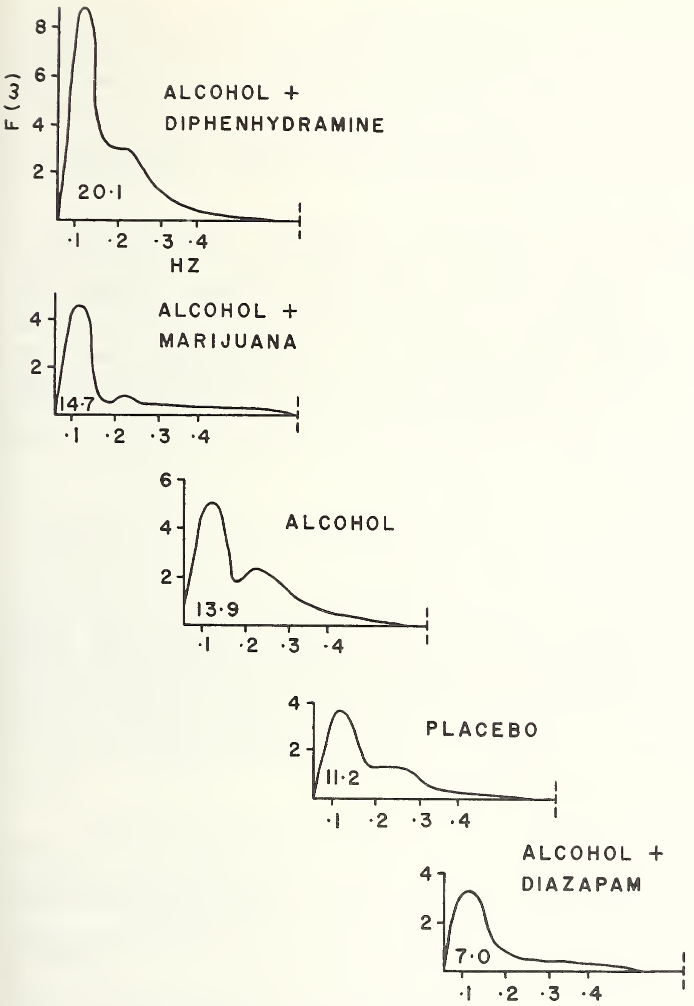


Figure 2 *Typical power spectra of steering wheel angle.*

level of significance). For the alcohol and marihuana condition, reaction time was significantly slower than for the placebo (0.10 level), alcohol alone (0.05 level) or alcohol and diazepam (0.05 level) condition. A trend was observed towards a faster reaction time on alcohol and diazepam than on alcohol alone or on the placebo. The means in order of increasing reaction time are: alcohol and diazepam, alcohol, alcohol and diphenhydramine, placebo, and alcohol and marihuana. Discussion and interpretation of these results will be left to a later report.

Cone Scores

For each subject and condition a cone score was calculated in which both the speed through the cone area and the number of cones knocked over were considered. Unfortunately, half the measurements of speed through the cone area are missing due to computer failure in this region. Not enough data were available to make meaningful tests for significant differences. However, the observed trend was that the best scores occurred for the placebo condition and the worst for the alcohol and marihuana condition. Scores for the other three conditions fell between these two extremes.

Stopping Accuracy

Stopping accuracy at the white line adjacent to the traffic signal was significantly (0.05 level) poorer under the alcohol condition than under the placebo condition. The effect that alcohol and marihuana had on stopping accuracy varied widely among the subjects. Two subjects made their best stop under this condition, another two made their worst stop under it. The conditions in order of decreasing mean stopping accuracy were: placebo, alcohol and diphenhydramine, alcohol and diazepam, alcohol, and alcohol and marihuana. Again, discussion and interpretation of the results for this measure will be left to a later report.

CONCLUSIONS

The results of this experiment show that alcohol alone and in combination with other drugs affects driving performance in different ways. Measures which most clearly differentiated between drug conditions were steering movement and average velocity. Further research in this area will be needed before the manner in which driving behaviour is affected by a drug can be related to physiological action of that drug.

REFERENCES

1. Bendat, J. S. and Piersol, A. G., *Measurement and Analysis of Random Data*, John Wiley and Sons Incorp., New York, 1966.
2. Hamilton, P. and Copeman, A., The Effect of Alcohol and Noise on Components of Attracting and Monitoring Task, *British Journal of Psychology 61*, 149, 1970.
3. Linnoila, N. and Mattilda, M. J., Drug Interaction on Cycle Motor Skills Related to Driving: Diazepam & Alcohol, *European Journal of Clinical Pharmacology 5*, 186, 1973.
4. Moskowitz, H., The Effect of Alcohol on Simulated Driving Behaviour of Alcoholics & Social Drinkers, *Report of the Institute of Transportation – Traffic Engineering Los Angeles*, University of California, 1971.
5. Sewell, R., A Data Acquision System for Studies of Driver & Vehicle Performance for Amateurs in Real Traffic Conditions, *Report LTR-ST533 National Research Council of Canada*, Ottawa, 1972.

Ethanol and Diazepam as Causative Agents in Road Traffic Accidents

O. Bø[1], J.F.W. Haffner, Ø. Langard, J. H. Trumpy, J. E. Bredesen and P.K.M. Lunde

The causal relationship between ethanol intoxication and road traffic accidents is well established (6, 12, 19, 29). Psychotropic drugs affect various mental and psychomotor functions (22), but the consequences for driving ability of continuous or intermittent intake of any such drug or drug combinations are less predictable than for ethanol alone. This problem, together with the increasing consumption of psychotropic drugs within our communities (2), makes it important to clarify whether, how and to what extent these drugs really affect traffic safety. Such knowledge is required to ensure adequate medical assessment and treatment in traffic accident cases, and to help formulate precise legislative measures regarding driving and intake of psychotropic drugs.

The aim of the present study was to determine the occurrence and amount of pre-accident ethanol and diazepam consumption, as verified by blood or plasma analyses, among hospitalized motor vehicle drivers. Ideally, an analytic screening for a wide variety of psychotropic drugs which may add to the road traffic accident hazard would have been desirable, but this was not possible, mainly due to limited laboratory facilities.

Diazepam was chosen as a marker substance because this drug alone represents approximately 85 per cent of the total sales of sedatives in Norway (16). Furthermore, diazepam has been shown to impair psychomotor functions considered to be of importance in driving (15, 20). These effects are even more pronounced if diazepam and ethanol intake is combined (21, 24).

METHOD

Subjects

The accident group These comprised all injured motor vehicle drivers admitted to the departments of general surgery (Depts. II and III) and neurosurgery (Dept. XIV) at Ullevaal Hospital, Oslo, during 1973. These departments receive the major part of serious road traffic casualties from Oslo, serving a population close on 500,000. Minor

---

[1] Surgical Department, Ullevaal Hospital, Oslo 1, Norway.

casualties are treated elsewhere, mainly at the Municipal Emergency centre of Oslo. Consequently, all patients included in the present material sustained comparatively serious injuries, needing surgical treatment or close observation. The accident group comprised 74 drivers; 69 were males (93.2%) and 5 females (6.8%).

The reference group[2] This group totalled 204 drivers, 21 female (10.3%) and 183 male (89.7%). These non-accident drivers attending routine medical check-ups were asked for consent to an additional blood sampling for scientific purposes; none refused. Blood samples were collected on working days, between 8.30 a.m. and 7.30 p.m. during April, May and June 1973. The drivers in the reference group were randomly selected and all were notified shortly before being tested in order to avoid any sample bias.

Blood Sampling

Two blood samples, each 2 ml venous blood, were collected in heparinized Vacutainer tubes from all accident-involved drivers. The first sample was drawn shortly after admission, and the second one hour later, for control and in order to determine the driver was on the ascending or descending part of the absorption-elimination curve. With one exception, the first value was the highest, both for diazepam and ethanol, and only the individual maximum values are given below. Only one blood sample was collected from drivers in the reference group. An appropriate amount of whole blood was decanted for ethanol analysis, and plasma for diazepam determination was obtained by immediate centrifugation of the remaining blood. The samples were stored at 4°C for a maximum of 2 days before being analyzed.

Determination of Ethanol

The determination of ethanol in whole blood was carried out by gas liquid chromatography as modified from Scott *et al* (28). Half a ml of whole blood was diluted directly with 4.5 ml of distilled water containing 200 μl N-propanol per litre as internal standard. An amount of 3 μl of this solution was injected into the gas chromatograph.

A Pye Unicam gas chromatograph 104 equipped with a single flame ionisation detector was used. A glass column (5 ft. x 4 mm i.d.) was packed with Porapak Q 100/120 mesh. The temperatures were 170°C in the column and 190°C in the injector. The flow rate of the nitrogen was 40 ml/min. The concentrations in the blood were calculated as mg ethanol/100 g blood from the peak heights, using standard curves prepared by subjecting aqueous solutions containing known concentrations of ethanol to the same procedure.

Determination of Diazepam

The determination of diazepam in plasma was carried out by gas liquid chromatography according to a modification of the method described by Berlin *et al* (4), which also allows measurement of the major active metabolite of diazepam, desmethyldiazepam. The method involves extraction of diazepam with 4 ml benzene from 0.1 ml plasma mixed with 0.1 ml of saturated KCl solution. Three ml of the benzene solution is evaporated to dryness under nitrogen at room temperature. The residue is dissolved in 100 μl benzene containing 0.5 mg griseofulvin/l as internal standard. An amount of 3 μl of this solution is injected into the gas chromatograph.

---

[2] The term 'reference group' was preferred to that of 'control group' because differences between nighttime and daytime, weekend and weekday driving and other variables concerning time were not taken into account. The problems of obtaining suitable control groups in accident studies are well known (7, 25).

A Varian Aerograph model 2100 equipped with a ^{63}Ni-detector was used. The silanized glass column (6 ft. x 2 mm i.d.) was packed with 3% OV-17 on 100/120 mesh Gas Chrom Q. The temperatures were 270°C in the injector, 247°C in the column and 310°C in the detector. The flow rate of the nitrogen was 30 ml per min. The plasma concentrations were calculated from the peak height, using standard curves prepared by subjecting plasma containing known concentrations of diazepam to the same procedure.

RESULTS

The age distributions in the reference and the accident groups are compared in Table I, which also shows the number of drivers in each age group with detectable ethanol, diazepam, or both, in their blood. There was a marked preponderance of young drivers in the accident group, 72% being 30 years old or less, as compared to 24% in the reference group. No obvious age group differences were seen among the accident involved drivers with regard to occurrence of detectable blood ethanol and/or diazepam.

TABLE I *Age Distribution of Motor Vehicle Drivers with and without Detectable Ethanol (E) and/or Diazepam (D).*

	Non-accident drivers		No. of accident-involved drivers					
	(Reference group)		*with* detectable		*without* detectable		Total	
Age	No.	%	E	D	E + D	E or D	No.	%
16 – 20	2	1.0	9	3	2	13	27	36.5
21 – 30	47	23.0	11	3	3	9	26	35.1
31 – 40	56	27.5	7	–	1	3	11	14.9
41 – 50	51	25.0	1	1	2	2	6	8.1
51 – 60	47	23.0	3	–	–	–	3	4.1
61 – 70	1	0.5	–	–	–	–	–	–
Above 70	–	–	–	–	–	1	1	1.3
All ages	204[a]	100.0	31	7	8	28	74[b]	100.0

[a] Twenty-one females (10.3%)

[b] Five females (6.8%)

The low number of female drivers both in the accident and the reference group (6.8% and 10% respectively) probably reflects the male/female driver ratio in Oslo. Roadside surveys from the U.S.A. indicate a similar sex distribution among drinking drivers (1). No conclusions can be drawn from our small series, regarding ethanol-or diazepam-influenced driving related to sex, but it is worth noting that only one female driver in the accident group had detectable ethanol and none had diazepam in their blood.

Information Concerning Ethanol and Diazepam Consumption

Questioning of accident-involved drivers about ethanol consumption in the pre-accident phase was deliberately avoided since subjects may fear that this information would have legal repercussions.

Thorough questioning of drivers by a doctor upon admission about use of drugs in general and especially diazepam was thought to be of some value. Information considered acceptable was obtained from 38 drivers with regard to diazepam. Inadequate or no information was obtained from 36 drivers in some cases because the patient was unable to co-operate due to his injuries, in others because he was discharged from the hospital before the information about use of diazepam was obtained (Table II).

TABLE II *Statement of Use of Diazepam Compared with Results of Plasma Diazepam Analysis.*

Statement	No. of drivers	Max. plasma diazepam levels (ng/ml): 0 (< 10)	10 – 50	51 – 300	>300
Diazepam used					
Daily	1	1	–	–	–
Occasionally	1	–	–	1	–
Last 4 days	4	1	–	2	1
Never	32	26	1	4	1
Total	38	28	1	7	2

Six drivers admitted that they had taken diazepam prior to the accident, and in four this statement was verified by the plasma analysis. Thirty-two drivers claimed that they had never used diazepam, but this statement was false in six cases (19%) as judged from the plasma diazepam analyses. As seen from Table I, diazepam alone or together with ethanol was detected in 15 of the patients in the whole accident group, ten of whom were questioned (Table II).

Drivers in the reference group were also asked about their consumption of drugs in general, and specifically asked about consumption of sedatives, hypnotics and analgesics during the last two days prior to blood sampling. In addition, they were asked whether they had taken diazepam, proprietary names of the drug being given.

Among the 204 reference drivers only five used diazepam regularly, and four had taken it during the last 48 hours. An additional four had taken other sedative or hypnotic drugs which might possibly impair driving ability (meprobamate, nitrazepam, chlordiazepoxide, dexchlorpheniramine (Phenamin^R)).

Blood Ethanol and Plasma Diazepam Levels

A total of 46 drivers in the accident group had detectable amounts of ethanol or diazepam, or both, in their blood. The individual results arranged by order of concentration are given in Figure 1.

Ethanol alone was found in 31 patients (41.8%) but five of these had blood ethanol levels below the statutory limit of 50 mg/100 g; accordingly 26 (35.1%) were

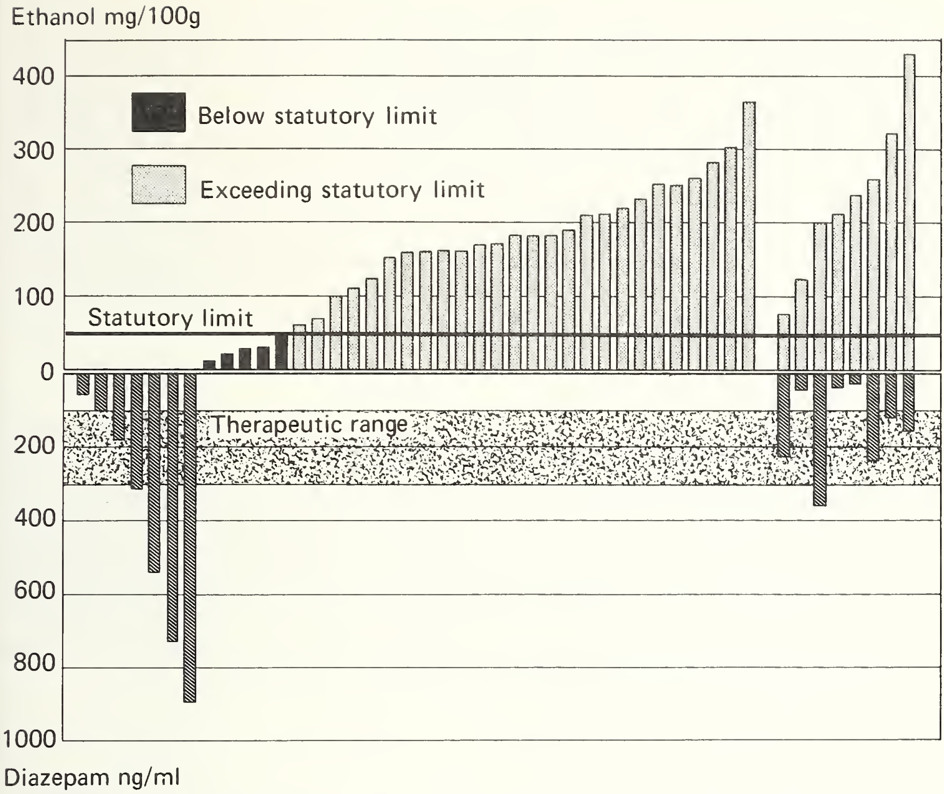


Figure 1 *Blood ethanol (upper part) and plasma diazepam (lower part) concentrations detected in 46 out of 74 hospitalized accident-involved motor vehicle drivers in Oslo, Norway 1973. Each column represents one driver. Seven had diazepam and 31 ethanol alone, while both agents were detected in eight patients. The term "therapeutic range" refers only to the fact that this steady state concentration range is commonly seen in subjects on a standard oral regimen of 10 mg diazepam per day (Bredesen & Lunde, unpublished observations).*

'intoxicated', *i.e.*, exceeded the legal threshold value. It is notable that of these 26, only five had blood levels below 150 mg/100 g. The remaining 21 (28.3%) had been drinking rather heavily prior to the accident, reaching an intoxication level which is usually clinically obvious, and definitely increases the crash involvement risk.

Diazepam alone was found in seven patients, and four (5.4%) had plasma concentrations exceeding the upper limit of the adopted 'therapeutic range', *i.e.*, above 300 ng/ml (Figure 1). Of the remaining three only one had a plasma level below 100 ng/ml, *i.e.*, an amount which alone is hardly of functional importance. It may therefore be stated that six drivers (8.1%) were influenced by diazepam to an extent which might impair their driving ability.

The combination of diazepam and ethanol was found in eight drivers (10.8%) of the accident group (Figure 1). Three of these had plasma diazepam levels below the lower limit of the adopted therapeutic range, four were within the therapeutic range, and one slightly exceeded the upper limit. As all eight had blood ethanol concentrations exceeding 50 mg/100 g however, even low concentrations of diazepam may be considered significant, since the effects of ethanol are probably enhanced (21, 24).

Thus, it can be stated that ethanol intoxication may have been a causative factor in 34 (26 + 8) of 74 road traffic accidents (45.9%). Accordingly, diazepam alone may have been a causative factor in six accidents (8.1%) and may, in combination with ethanol, represent a contributory factor in another eight accidents (10.8%). The two agents, either alone or in combination, may have played a part as principal or contributing cause in 54.1% of the 74 road traffic accidents in the present series.

In comparison, as seen from Table IV, only seven (3.4%) subjects in the reference group had detectable amounts of either ethanol or diazepam in the blood. Two drivers with detectable ethanol had only 20 mg/100 g blood; however, a third driver had 110 mg/100 g. Four drivers with detectable diazepam had plasma levels of 32, 125, 205 and 238 ng/ml.

Hour of the Day

The time when the first blood sample was collected from the 74 hospitalized drivers was registered and the material grouped (Table III). In Oslo, hospitalization is usually effected within one hour after the accident. Thus the time lag between accident and blood sampling would not exceed one and a half hours. The major part of accidents occurred in the evening and at night, and ethanol was significantly more commonly detected among the drivers with night accidents ($p < 0.001$, Bernoulli test). The same applies to those with ethanol and diazepam combined, whereas those with diazepam alone showed no preponderance at night. This may be explained by the slow elimination of this drug as compared to ethanol.

TABLE III *Time of First Blood Sample Collection for Analysis of Ethanol (E) and Diazepam (D) in 74 Accident-Involved Drivers*

Time period	No. of drivers *with* detectable E	D	E + D	Total	No. of drivers *without* detectable E or D
6 – 12 a.m.	4	2	–	6	8
12 a.m. – 6 p.m.	5	3	–	8	5
6 – 12 p.m.	8	1	6	15	9
12 p.m. – 6 a.m.	14	1	2	17	6
Total	31	7	8	46	28

In Table IV the number of daytime accident drivers with detectable ethanol and/or diazepam in their blood are compared to those from the reference group. As can be seen, ethanol and diazepam were found much more commonly among the accident-involved drivers than in the reference group.

TABLE IV *Blood Ethanol (E) and Plasma Diazepam (D) Among Day-Time (6 a.m. – 6 p.m.) Accident-Involved Drivers and in the Reference Group*

Detected agent	Accident group (No. of drivers)	Reference group (No. of drivers)
E	9	3
D	5	4
E + D	–	–
Total	14 (51.9%)	7 (3.4%)

Day of the Week

As seen from Table V, ethanol or diazepam was more frequently detected among accident drivers during weekends (Friday 6 p.m.-Sunday 6 a.m.) than on working days and Sundays or holidays ($p < 0.001$). Road traffic accidents in general tend to increase towards the end of the week (7, 18, 27), and roadside surveys (8) have shown that drunken driving reaches its peak on Friday and Saturday even in non-accident series.

TABLE V *Number of Accident-Involved Drivers with Detectable Ethanol (E) and Diazepam (D) on Various Days of the Week*

Time of accident	E	D	D + E	Total
Working-days	11	6	4	21
Fridays 6 p.m. - Sundays 6 a.m.	18	1	3	22
Sundays & Public Holidays from 6 a.m. to 6 a.m. the next day	2	–	1	3
Total	31	7	8	46

Type of Injury

As mentioned above, the accident group includes patients treated both in the general surgical units, and in the neurosurgical department. The allocation of the patients was decided either by the ambulance doctor or by the receiving surgeon upon admittance. The patients admitted to the neurosurgical unit had predominantly head injuries, and this type of injury was the commonest cause of hospitalization in this series as in many others (3, 7, 13, 27). Fifty of the 74 patients were treated in the department of neurosurgery. Thirty-two of these 50 patients (62.0%) had detectable ethanol and/or diazepam in their blood, as compared to 14 (58.3%) of the 24 patients treated in general surgical departments. Thus, there appears to be no difference in prevalence of intoxication in the various types of injuries.

Type of Vehicle

Among 13 motorcycle drivers in the accident group, ethanol was detected in six and diazepam in two; none had taken both agents. Among 61 car drivers, 25 had ethanol, 5 diazepam and 8 both, in their blood. No significant difference was found between motorcycle drivers and car motorists concerning the use of ethanol and/or diazepam prior to the accident.

DISCUSSION

The accident group of the present series represents a selection from the average population of accident-involved drivers who were seriously injured and needed hospitalization or close observation.

A total of 40 drivers (54.1%) had detectable ethanol in their blood. Thirty-four of these (45.9%) were 'intoxicated', *i.e.*, exceeded by far the legal limit of 50 mg/100 g blood which is unexpectedly high. Here it must be recalled that Norway has stuck to a very strict and unchanged traffic alcohol legislation since 1936, and also to a court practice more rigorous than most other countries (9) – both measures thought to be highly deterrent. Bϕ (7) found that 9.9% of accident-involved motor vehicle drivers in the calendar year 1968 had ingested ethanol. This material comprised hospitalized as well as out-patient drivers with minor injuries, a selection difference which, to some extent, explains the discrepancy between the two materials. The present investigation indicates, therefore, that ethanol is a more common causative factor in serious road traffic accidents in our country than hitherto assumed, and possibly also that the problem is increasing.

In addition, heavy drinking seems to be common among accident-involved drivers. This contrasts strongly with the drinking pattern of Norwegian non-accident drivers, among whom social drinking was found to be common, whereas heavy drinking was comparatively rare (8). No other data suited to evaluate the drunken driving incidence in Norway were available, but from other countries several authors (10,11, 14, 23) have reported frequencies of ethanol-influenced driving equal to or even higher than those in the present series.

In our accident group diazepam alone was detected in seven and together with ethanol in another eight patients, *i.e.*, in 20.3% of the whole group. The major metabolite of diazepam, desmethyldiazepam was also regularly identified, but not quantitated, thus representing an additional confirmation that the substance detected really was diazepam. The discrepancy between the patients' statements about diazepam consumption and the analytical results (Table II) thus demonstrates the need for analytical verification and control of drug anamnestic information in this type of study.

Knowledge about diazepam use or abuse among motor vehicle drivers in Norway is scanty (5, 7), and comparable data are not available. Hansson (17) reported that of 29 accident-involved drivers in Sweden three had taken sleeping pills or tranquillizers prior to the accident and 26 had been drinking.

Assuming an average dose of 10 mg diazepam per day, Norwegian diazepam sales figures (16) imply that 85,000 Norwegians (2.1% of the entire population) could be on continuous treatment, or approximately 1 million (25%) could receive one month's treatment with this drug every year. Still, the percentage of accident drivers with detectable diazepam in their blood (20.3%) is much higher than would be expected on an average basis, a fact which is also apparent when making comparisons with the reference group. If we consider only accident drivers with diazepam above the therapeutic range and, in addition, those with 'therapeutic levels' of diazepam combined with ethanol, as a potential risk group, the percentage is somewhat reduced (12.1%), but far from negligible. A complete evaluation of the plasma concentration/effect relationship in connection with driving ability will also have to include active metabolites of diazepam, especially desmethyldiazepam (26). The plasma concentration ratio between diazepam and this metabolite may vary more than two-fold under steady state conditions (4) and is even more difficult to predict during start and after termination of diazepam medication. Analysis of these problems was beyond the aim of the present study.

From our study it seems apparent that diazepam consumption represents a significant but, compared to ethanol, a relatively minor causative factor in serious road traffic accidents in Norway. If prescribed and used properly, the risk/benefit-ratio by legal use can presumably be reduced to an acceptable minimum, especially if combination with ethanol is avoided. On the other hand, there is no doubt that illegitimate use, misuse, and abuse of diazepam and similar drugs is gradually becoming more widespread. Specific countermeasures to combat this new threat to road traffic safety are therefore highly desirable.

SUMMARY

Blood ethanol and plasma diazepam levels were determined in 74 hospitalized accident-involved drivers during 1973 in Oslo, Norway. The results were compared to those from a reference group of 204 drivers, attending routine medical checkups. In the accident group, ethanol alone was detected in 31 (41.8%), diazepam alone in seven (9.4%) and ethanol combined with diazepam in eight (10.8%) drivers. In the reference group the corresponding numbers were three (1.5%) and four (2.0%), none with the combination. Forty (54.1%) of the accident-involved drivers as compared to four (2.0%) of the reference group, had driven with blood ethanol and/or plasma diazepam concentrations assumed sufficiently high to impair driving ability. Six (8.1%) of those had taken diazepam alone, eight (10.8%) diazepam combined with ethanol, and 26 (35.1%) ethanol alone. Both the extent and the degree of intoxication was most pronounced with ethanol, 21 having 150 mg or more/100 g blood. Regular or intermittent use of diazepam and other psychotropic drugs may significantly add to the problem of traffic safety, but ethanol is still the major, and presumably also an underestimated, causative factor in serious road traffic accidents in Norway.

REFERENCES

1. Alcohol Safety Projects. Volume I, Summary, U.S. Department of Transportation, Office of Alcohol Countermeasures, Washington, D.C., 1972.
2. Balter, M. B., Levine, J. and Manheimer, D. J., Cross-national Study of the Extent of Anti-anxiety/Sedative Drug Use. *New England and Journal of Medicine* 290, 769-773 (1974).
3. Bäckstrøm, C.-G., Traffic Injuries in South Sweden. *Acta chirurgica Scandinavica Supplement* 308 (1963).
4. Berlin, A. B., Siwers, B., Agurell, S., Hiort, A., Sjöqvist, F. and Strøm, S., Determination of Bioavailability of Diazepam in Various Formulations from Steady State Plasma Concentration Data. *Clinical Pharmacology and Therapeutics* 13, 733-744 (1972).
5. Blikra, G. and Ringkjøb, R. *Personskader ved trafikkulykker behandlet i Ullevål sykehus 1966*. Report no. 2, The Norwegian Committee of Traffic Safety Research, Oslo, Norway, 1968.

6. Borkenstein, R. F., Crowther, R. F., Schumate, R. P., Ziel, W. B. and Zylman, R. *The Role of the Drinking Driver in Traffic Accidents.* Department of Police Administration, Indiana University, Bloomington, Indiana, 1964.
7. Bφ, O., *Road Casualties.* Scandinavian University Books, Oslo-Bergen-Tromsφ, Norway, 1972.
8. Bφ, O., *"Screening" av alkoholbelastning blandt bilfφrere i normal trafikk.* Report no. 102 from The Institute of Transport Economy, Oslo, Norway, 1972.
9. Bφ, O., *Alcohol and Drug Countermeasures in Norway, and Some Results from an Investigation of the Drinking-driving Incidence in Oslo.* Unpublished paper read at the OECD Symposium on Countermeasures to Driver Behaviour under the Influence of Alcohol and other Drugs, London, BMA House, 1971.
10. Campbell, H. E., Traffic Deaths go up Again. *Journal of the American Medical Association* 201, 183-186 (1967).
11. Chetta, N. J., Alcohol, Drugs and Driving. *J. La. med Soc.* 119, 344-347 (1967).
12. Freudenberg, K., Unfallschance und Blutalkohol. *Blutalkohol* 2, 226-274, 1963/1964.
13. Gφgler, E., Chirurgie und Verkehrsmedizin. In *Handbuch der Verkehrmedizin,* Springer Verlag, Berlin, Heidelberg und New York, 1968.
14. Haddon, W. and Bradess, V.A., Alcohol in the Single Vehicle Accident, Experience of Westchester County, New York. *Journal of the American Medical Association.* 169, 1 587-1 593 (1959).
15. Haffner, J.F.W., Mφrland, J., Setekleiv, J., Strφmsaether, C. E., Danielsen, A., Frivik, P. T. and Dybing, F., Mental and Psychomotor Effects of Diazepam and Ethanol. *Acta pharmacol. & toxicol.* 32, 161-178 (1973).
16. Halse, M., Halvorsen, I. K. and Lunde, P.K.M., Salg av psykofarmaka og hypnotika i Sverige og Norge – basert på dosestatistikk. *Tidsskrift for den Norske Laegeforening.* 93, 2 595-2 597 (1973).
17. Hansson, C., *Alkohol och läkemedel vid dödsolyckor i trafiken i södra Sverige 1972* (personal communication).
18. Heikel, H.V.A., Trafikolycksfallskadornas förändringar under 10-års perioden 1951-1960. *Nordisk medicin* 73, 125-133 (1965).
19. Holcomb, R. J., Alcohol in Relation to Traffic Accidents. *Journal of the American Medical Association* 111, 1 076-1 085 (1938).
20. Linnoila, M. and Mattila, M. J., Drug Interaction on Psychomotor Skill Related to Driving: Diazepam and Alcohol. *Europ. J. Clin. Pharmacol.* 5, 186-194 (1973).
21. Linnoila, M. and Häkkinen, S., Effects of Diazepam and Codeine, Alone and in Combination with Alcohol, on Simulated Driving. *Clinical Pharmacology and Therapeutics* 15, 368-373 (1974).
22. Linnoila, M. and Mäki, M., Acute Effects of Alcohol, Diazepam, Thioridazine, Fluopenthixole and Atropine on Psychomotor Performance Profiles. *Arzneimittel-Forschung* 24 565-569 (1974).
23. McCarrol, J. R. and Haddon, W., A Controlled Study of Fatal Accidents in New York City. *Journal of Chronic Diseases* 15, 811-826 (1962).
24. Mφrland, J., Setekleiv, J., Haffner, J.F.W., Strφmsaether, C. E., Danielsen, A. and Holst-Wethe, G., Combined Effects of Diazepam and Ethanol on Mental and Psychomotor Functions. *Acta pharmacologica et toxicologica* 34, 5-15 (1974).
25. Novak, J. W. and Shumate, R. P., The Use of "Control Groups" in Highway Research. *Traffic Safety* 5, 20-24 (1961).
26. Randall, L. O. and Kappell, B., Pharmacological Activity of Some Benzodiazepines and Their Metabolites. In *The Benzodiazepines.* Garattini, S., Mussini, E. and Randall, L. O., (eds.) Raven Press, N.Y. 1973, pp. 27-51.
27. Rugtveit, A., Trafikkskader. *Tidskrift for den norske Laegeforening* 5, 429-435 (1963).
28. Scott, C., Hadden, N. and Bonelli, E. J., Analysis of Alcoholic Beverages. In *Manual from Varian Aerograph.* Walnut Creek, California, U.S.A. 1966.
29 Vamosi, M., Experiences with Non-alcoholic Road Traffic in Czechoslovakia. Alcohol and Road Traffic. *Proceedings of the Third International Conference,* London 1962, BMA House, London 1963.

Drug After Effects and Traffic Safety

A.E. LeBlanc[1] and A. Wilson

The relevance of alcohol and other drugs to traffic safety has been studied from many perspectives and a great deal of information has come to light. The emphasis, however, has been on the presence of drugs in the body and their consequent influence on behavior related to driving. If we are to understand the total picture regarding drugs and traffic safety, we must consider the after effects, that is, the effects on behavior which persist after the drug has been eliminated from the body.

The offset of alcohol effects have been studied to some degree and no one would be surprised to find that the presence of frank convulsions, hallucinations, and other dramatic manifestations of the alcohol withdrawal syndrome would impair driving. However, the occurrence of this phenomenon is relatively rare. What is important, though, are the effects which are not as salient but which are nonetheless disruptive to driving skills. In today's world where drug taking (whether it be coffee, cigarettes, barbiturates, marijuana or alcohol) and driving are an everyday occurrence, there is a pressing need to examine more closely these subtle 'hangover' effects.

For example, studies have shown (8, 10, 14, 20) that even after a single exposure to alcohol there are important decrements in performance which can be seen 12 to 18 hours later when the blood alcohol level is zero. Similar studies (12, 23) have investigated the effect of alcohol on REM sleep which, in turn, can be shown to impair concentration, induce anxiety and detrimentally affect the vestibular-ocular reflex (6, 7).

Other drugs such as sedative-hypnotics, tranquilizers and marijuana (21, 24) have been shown to cause similar sleep disturbances to varying degrees. This rather indirect after-effect of drugs poses a real danger in terms of traffic safety. It is increasingly common for physicians to warn their patients if these drugs are prescribed, and for the manufacturers of over-the-counter drug preparations to warn the user of the possible detrimental effects regarding the operation of machinery, including automobiles. The warning about potential offset effects is very rarely given.

The hallucinogens present another important potential disturbance that outlasts the presence of the drugs. There is reliable documentation of the so-called flashback phenomen for LSD (13, 19) and to a lesser extent, marijuana (1, 11). Whether this recurrence of some of the characteristic drug effects is explained by conditioning paradigms or physiological mechanisms is not important. With the widespread use of marijuana there are definite implications here concerning traffic safety. The flashback phenomenon is probably so rare as to be largely academic, though it might be useful in explaining certain traffic accidents which otherwise seem inexplicable.

---

[1] Addiction Research Foundation, 33 Russell Street, Toronto, Canada.

The ingestion of nicotine in cigarettes and caffeine in assorted beverages has been shown to produce tolerance and dependence (2, 4, 9, 10). Termination of the use of these compounds, whether for health or other reasons, produces physiological and psychological disturbances. In this regard, most people can look to their own experience. The disturbance of mood, autonomic and motor function that you see or have experienced are *real* and detrimental to traffic safety (18).

There is another class of offset effect which is very important. A small and certainly controversial body of data is accumulating which indicates that chronic exposure to drugs may produce permanent or semi-permanent brain damage. We are all aware of the varieties of brain syndromes associated with the chronic use of alcohol. These disorders may involve gross damage with brain atrophy or more subtle damage with confusion and loss of memory as the key symptoms. In any case, these phenomena are certainly detrimental to driving.

Opiates have recently been shown to be involved in cell destruction in a deep nucleus of the brain, the globus pallidus (15). The globus pallidus plays a role in autonomic activity and motor function.

The phenothiazines, long used effectively in the management of some mental disorders, produce some motor dysfunction. This was believed to be annoying while present, but completely reversible upon termination of medication. Recently, however, a motor disorder – tardive dyskinesia – has been shown to develop and persist after medication has been stopped (5).

Cannabis has also been implicated in brain damage with protracted use (3). If these data stand up, then cannabis users will probably be the second largest of the drug-induced brain damage group. Stimulants have been shown to produce deterioration of the brain's blood vessels (16, 17). Here again are definite implications for traffic safety.

Industrial exposure to chemicals and metals is another area of potential hazard (22). The recent lead exposure publicity in Toronto makes us more aware of the potential dangers to workers and neighbouring residents alike. The long-term effects of industrial toxicity are equally implicated when one considers driving skills. Up until this time there has been very little direct investigation of the effects of industrial toxicity on skills related to driving, but there seems to be a growing awareness of the need for such research.

In summary, drugs may be said to produce three main disturbances which persist after the drug has disappeared.

1) The withdrawal phenomenon which varies from chemically important to barely detectable by sophisticated technology.

2) After effects exemplified by the LSD and marijuana flashbacks.

3) More permanent brain damage which varies in intensity from the dramatic brain shrinkage produced by alcohol to the "amotivational syndrome" said to be produced by cannabis. This category includes the insidious effects of environmental and industrial chemicals as well.

Even though it is difficult to research this field with respect to the absolute involvement in vehicular safety of the *absence* of various drugs, there are some steps which can be considered, given the data accumulated to date.

The consequences of the withdrawal effects of drugs can be partly countered by an educational program for clinicians, manufacturers, and the public as to the potential risks. It is to be hoped that this will result in an awareness that the period of risk in drug use extends beyond the duration of drugs in the body and that behavior should be governed accordingly.

The third class of drug after-effects requires some consideration with respect to automobile licensing practices. Currently in Canada a driving license, once issued, is renewable without testing for one's adult life. As the data accumulate, thought should be given as to whether the chronic drug or alcohol user, even if he becomes abstinent, should be denied the right to drive at all or at least have that right restricted in some way.

REFERENCES

1. Annis, H. M. and Smart, R. G. Adverse Reactions and Recurrences from Marijuana Use. *British Journal of Addiction to Alcohol and Other Drugs.* 68, 315-319 (1973).
2. Brown, B. B., Some Characteristic EEG Differences between Heavy Smoker and Non-smoker Subjects. *Neuropsychologia* 6, 381-388 (1968).
3. Chopra, G. S., Studies on Psycho-clinical Aspects of Long-term Marijuana Use in 124 Cases. *International Journal of Addictions* 8 (6), 1015-1026 (1973).
4. Colton, T., Gosselin, R. E. and Smith, R. P. The Tolerance of Coffee Drinkers to Caffeine. *Clinical Pharmacology and Therapeutics* 9, 31-39 (1968).
5. Crane, G. E. Factors Predisposing to Drug-induced Neurologic Effects. In *Phenothiazines and Structurally related Drugs.* I.S. Forest, C.J. Carr and E. Usdin (eds) Raven Press, New York, 269-279, 1974.
6. Dement, W. C. The Effect of Dream Deprivation. *Science* 131, 1705-1707 (1960).
7. Dement, W. C. and Fisher, C. Experimental Interference with the Sleep Cycle. *Canadian Psychiatric Association Journal* 8, 400-405, (1963).
8. Dowd, P. J., Wolfe, J. W. and Cramer, R. L. Aftereffects of Alcohol on the Perception and Control of Pitch Attitude during Centripetal Acceleration. *Aerospace Medicine* 44, 928-930 (1973).
9. Dreisbach, R. H. Experimental Caffeine Withdrawal Headache (Abst.). *Journal of Pharmacology and Experimental Therapeutics* 69,283 (1940).
10. Hutchinson, R. R. and Emley, G. S. Effects of Nicotine on Avoidance, Conditioned Suppression and Aggression Response Measures in Animals and Man. In *Smoking Behavior*, W. L. Dunn, Jr. (ed.) V. H. Winston & Sons Inc., Washington, 1973.
11. Keeler, M. H., Reifler, C. B. and Liptzin, M. B. Spontaneous Recurrence of Marijuana Effect. *American Journal of Pyschiatry* **125**, 140-142, 1968.
12. Knowles, J. B., Laverty, S. G. and Kuechler, H. A. Effects of Alcohol on REM Sleep. *Quarterly Journal of Studies on Alcohol* 29, 342-349 (1968).
13. Mattefy, R. E. Behavior Therapy to Extinguish Spontaneous Recurrences of LSD Effects: A Case Study. *Journal of Nervous and Mental Diseases* 156, 226-231 (1973).
14. Pawan, G.L.S. Alcoholic Drinks and Hangover Effects. *Proceedings of the Nutrition Society* 32, 15A (1973).
15. Pearson, J., Baden, M. B. and Richter, R. W. Neuronal Depletion in the Globus Pallidus of Heroin Addicts. *Report of the 36th Annual Scientific Meeting Committee on Problems of Drug Dependence*, National Academy of Sciences, Washington, 1974, pp. 187-199.
16. Rumbaugh, C. L., Bergeron, R. T., Scanlan, R. L., Teal, J. S., Segall, H. D., Fang, H.C.H. and McCormick, R. Cerebral Vascular Changes Secondary to Amphetamine Abuse in the Experimental Animal and Cerebral Angiographic Changes in the Drug Abuse Patient. *Neuroradiology* 3, 54 (1971a).
17. Rumbaugh, C. L., Bergeron, R. T., Scanlan, R. L., Teal, J. S., Segal, H. D., Fang, H.C.H. and McCormick, R. Cerebral Angiographic Changes in the Drug Abuse Patient. *Radiology* 101, 335-344 (1971b).

18. Selzer, M. L., Rogers, J. E. and Kern, S. Fatal Accidents: The Role of Psychopathology, Social Stress and Acute Disturbance. *American Journal of Psychiatry* **124**, 1028-1036 (1968).

19. Smart, R. G. and Bateman, K. Unfavourable Reactions to LSD: a Review and Analysis of the Available Case Reports. *Canadian Medical Association Journal* 97, 1214-1221 (1967).

20. Takala, M., Siro, E. and Toivainen, Y. Intellectual Functions and Dexterity during Hangover. *Quarterly Journal of Studies on Alcohol* 19, 1-29 (1958).

21. Von Felsinger, J. M., Lasagna, L. and Beecher, H. K. The Persistence of Mental Impairment Following a Hypnotic Dose of a Barbiturate. *Journal of Pharmacology* **109**, 284-291 (1953).

22. Xintaras, C., Johnson, B. L. and deGroot, I. (eds), *Behavioral Toxicity: Early Detection of Occupational Hazards.*, U.S. Department of Health, Education and Welfare, Washington, 1974.

23. Yules, R. B., Freedman, D. V. and Chandler, K. A. The Effects of Ethyl Alcohol on Man's Electroencephalographic Sleep Cycle. *Electroencephalography and Clinical Neurophysiology* **20**, 109-111 (1966).

24. Zarcone, V. P., Jr., Marijuana and Ethanol: Effects on Sleep. *Psychiatry in Medicine* **4**, 201-212 (1973).

Interactions of Some Street Drugs

Blake B. Coldwell[1,2], Barry H. Thomas and Keith Bailey

In Canada, alcohol presents the greatest hazard of all the psychoactive, addicting drugs (13). The most common drugs ingested with alcohol are the barbiturates (6, 7, 11). While the toxicity of ethanol-barbiturate combinations has been well documented (1, 12), the biochemical and physiological changes associated with this toxicity are not thoroughly understood. The widespread use of marihuana has focused attention on its potential for causing harmful effects in man. One area, that of its interaction with other drugs, has received some attention in our laboratories (2). The purpose of this paper is to review, briefly, our laboratory studies with animals concerning the interactions of alcohol and marihuana components with other CNS drugs. We believe these observations may help to explain, at least in part, some of the pharmacological and toxicological effects of such drug combinations observed in man.

ALCOHOL AND BARBITURATES

Acute Toxicity

Ethanol (15% w/v) and barbiturates were administered simultaneously by the intraperitoneal route to overnight-fasted, male albino rats of the Wistar strain. The 24-hr LD50 values of the barbiturates were determined at ethanol doses of 0, 2, 3 and 4 g/kg. The effect of ethanol (3g/kg) on barbiturate sleeping time was also investigated. The results of these studies are summarized in Figures 1 and 2.

The presence of ethanol produced a dose-dependent decrease in the LD50 values of all five barbiturates examined (thiopental, pentobarbital, amobarbital, phenobarbital and barbital); the effect being most pronounced with the more slowly metabolized hypnotics. Similarly, ethanol greatly prolonged the barbiturate sleeping time, the effect being most pronounced with the long-acting members (16).

---

[1] Drug Research Laboratories, Health Protection Branch, Health and Welfare Canada, Ottawa, Canada, K1A 0L2.

[2] Many persons have contributed to the investigations reviewed in this paper, especially Drs. G. S. Wiberg, H. L. Trenholm, B. H. Thomas, K. Bailey and L. Whitehouse, and Messrs. C. J. Paul, G. Solomonraj and W. Zeitz.

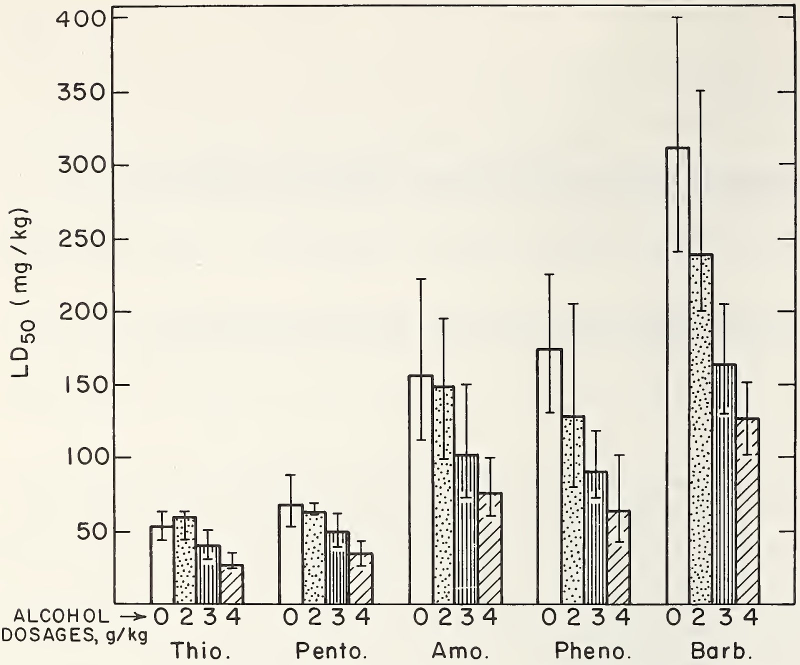


Figure 1 *The effects of ethanol on the 24 hour LD50 of barbiturates in rats. Figures on the abscissa are doses of ethanol (g/kg).*

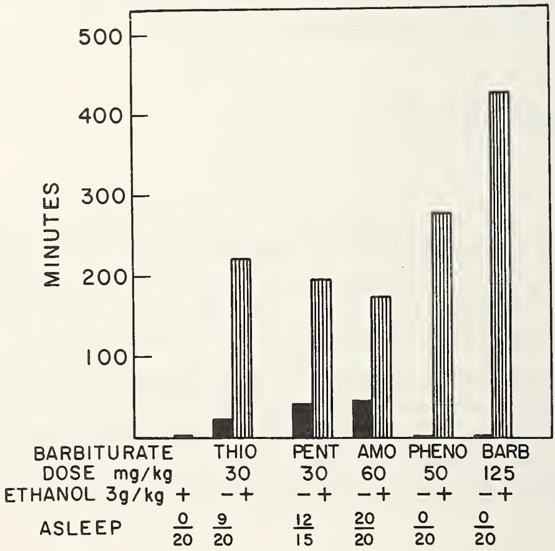


Figure 2 *The effect of ethanol (ip, 3g/kg, 15% w/v aqueous solution) on the median sleeping time induced by ip administration of threshold hypnotic doses of thiopental (thio, 30mg/kg), pentobarbital (pent, 30mg/kg), amobarbital (amo, 60mg/kg), and subthreshold hypnotic doses of phenobarbital (pheno, 50mg/kg), and barbital (barb, 125mg/kg) to groups of 15-20 rats. The barbiturates were administered alone (■) and simultaneously with ethanol (▥).*

Pharmacokinetic Investigations

We have investigated the effect of an acute dose of ethanol (3g/kg as a 15% w/v solution) on the pharmacokinetics of pentobarbital (15) and phenobarbital (3). With both barbiturates, the presence of ethanol caused elevated brain levels of the pharmacologically active unchanged drug. This increase was due to alcohol inhibition of barbiturate biotransformation to polar metabolites. These observations are summarized in Figures 3, 4, 5, and 6. Figure 3 shows that many tissues had higher levels of radioactivity, emanating from ^{14}C-pentobarbital, when ethanol was administered with the drug. Figure 4, summarizing the urinary excretion data for the major metabolites of pentobarbital, indicates that ethanol caused a marked reduction in the excretion of M-1, believed to be 5-ethyl-5-(1-methyl-3-carboxypropyl) barbituric acid, and an increase in M-IV, 5-ethyl-5-(3-hydroxy-1-methylbutyl) barbituric acid. Figure 5 shows the effect of ethanol on the level of radio-activity in the liver and brain of rats administered ^{14}C-phenobarbital, alone and with ethanol. Figure 6 illustrates that ethanol-treated rats excreted less p-hydroxy-phenobarbital, the major metabolite of phenobarbital, than the control animals.

In all of these experiments, no metabolites of pentobarbital or phenobarbital were detected in the brain and the barbiturate blood:brain ratios were similar in alcohol and non-alcohol treated rats. Thus the enhanced levels of radioactivity in the brains of the ethanol-treated animals is due to the unchanged drug, which could account for some of the toxicity of ethanol-barbiturate combinations. Further, there is no evidence that an intoxicating dose of ethanol facilitated the passage of the barbiturates from blood to brain (4). While the barbiturates do not affect the rate at which ethanol disappears from the blood, they appear to cause changes in the blood and brain concentrations of acetaldehyde and acetone in ethanol-treated animals (5). These effects may also contribute to the toxicity.

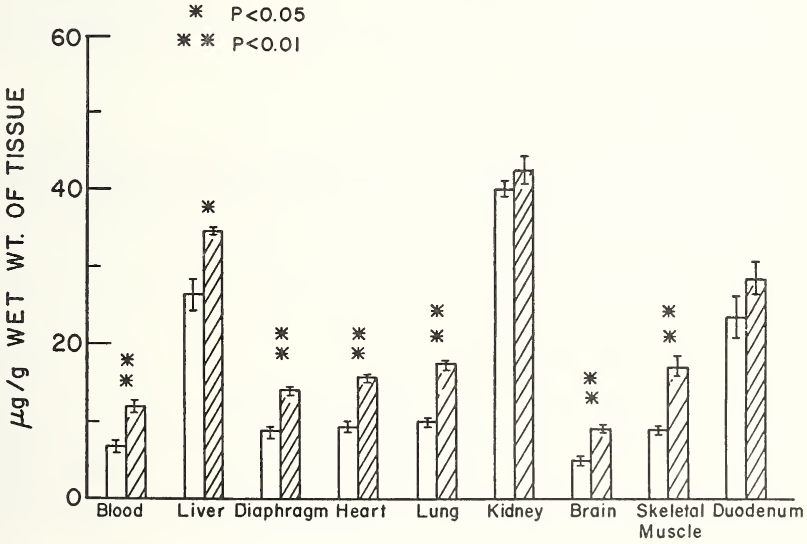


Figure 3 *Tissue distribution of radioactivity expressed as pentobarbital (µg/g wet weight) in groups of three rats 3 hours after ip injection of ^{14}C-pentobarbital (30mg/kg) and either 15% ethanol (3g/kg,▨) or saline control (▭). The figures are means with standard errors.*

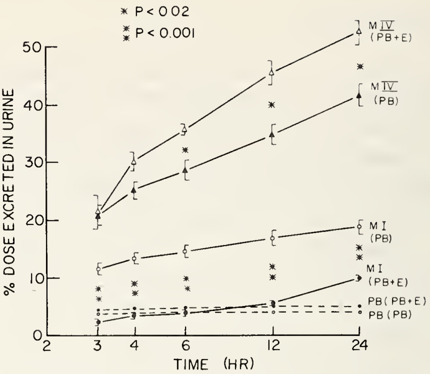


Figure 4 *The cumulative excretion of pentobarbital and its metabolites in rat urine after either pentobarbital and ethanol (PB+E) or pentobarbital and saline control (PB). The figures, expressed as a percentage of the dose of ^{14}C-pentobarbital (30mg/kg), are means with standard errors. The dose of ethanol was 3g/kg (7.5% w/v solution in saline) and both drugs were administered orally. N=6.*

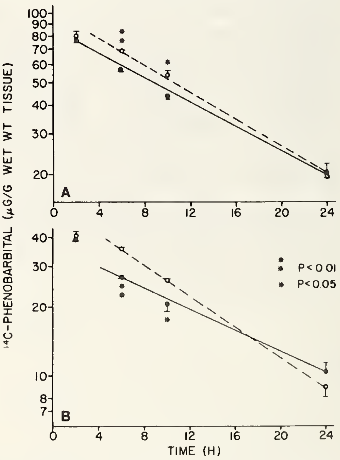


Figure 5 *Radioactivity in liver (A) and brain (B), expressed as phenobarbital (µg/g wet weight) from rats treated orally with ^{14}C-phenobarbital (50mg/kg), alone (—●—), and with ethanol (3g/kg, 7.5% w/v aqueous solution, --0--). Each point represents the mean± standard error in 4 animals.*

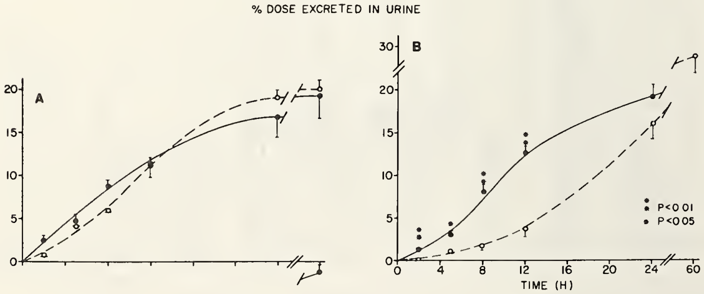


Figure 6 *Cumulative excretion of phenobarbital (A) and p-hydroxyphenobarbital (B) in rat urine, expressed as percentages of the dose of ^{14}C-phenobarbital administered (50mg/kg, orally) alone (—●—) and with ethanol (3g/kg, 7.5% w/v aqueous solution, --0--). Each point represents the mean±standard error of three animals.*

ALCOHOL AND OTHER DRUGS

Amphetamine

The effect of ethanol on the toxicity and metabolism of amphetamine in male Swiss Webster mice was investigated. The mouse was chosen because amphetamine metabolism in this species proceeds to a significant extent through the oxidative pathways which are believed to predominate in man (8). Amphetamine exhibits a biphasic LD50 response in mice (9, 10). In our experiments ethanol (3g/kg) reduced the mortality caused by low doses of amphetamine but did not significantly alter the lethality of high doses. Urinary excretion studies indicated that ethanol inhibited amphetamine metabolism (Table I).

TABLE I *Effect of Ethanol (E) on the Urinary Excretion of Amphetamine (A) and Metabolites.*[a,b]

Compound	A	A + E_2	A + E_3
Amphetamine	43.9 ± 3.6	64.4 ± 5.1	68.6 ± 1.4
p-Hydroxyamphetamine	3.7 ± 0.6	2.2 ± 0.2	1.9 ± 0.3
p-Hydroxyamphetamine glucuronide	14.4 ± 0.8	8.5 ± 0.4	4.7 ± 0.3
Hippuric acid	20.6 ± 2.3	19.3 ± 1.8	18.9 ± 1.6
Unknown I	1.5 ± 0.3	1.5 ± 0.6	1.0 ± 0.5
Unknown II	15.9 ± 4.9	4.2 ± 3.3	4.9 ± 2.1
Total dose excreted, %	70.6	62.2	55.9

[a] In the 6 hour period immediately following ip administration to non-grouped mice.

[b] ^{14}C-d-Amphetamine sulfate (10mg/kg) was administered alone or with ethanol (15% w/v aqueous solution) at 2 (E_2) and 3 (E_3)g/kg. The results are expressed as a percentage (mean ± S.E.) of the total amount of radioactivity excreted in 6 hours.

Diazepam

Recently, we have investigated the effect of ethanol on the pharmacokinetics of diazepam in the rat. Some of the data are summarized in Figure 7. The brains from rats treated with diazepam plus ethanol (3g/kg), compared to those from rats given diazepam alone, contained significantly more unchanged diazepam and monohydroxylated derivatives, indicating ethanol inhibition of metabolism.

Isoniazid

Preliminary data indicate that ethanol may alter the metabolism of isoniazid in rats. In the presence of ethanol and after oral administration of isoniazid, the excretion of isonicotinic acid and isonicotinoyl glycine was reduced and that of N-acetylisoniazid was increased relative to the amounts excreted by control animals.

Δ^9 tetrahydrocannabinol

The metabolism of this component of marihuana in rats was not altered by the simultaneous administration of ethanol.

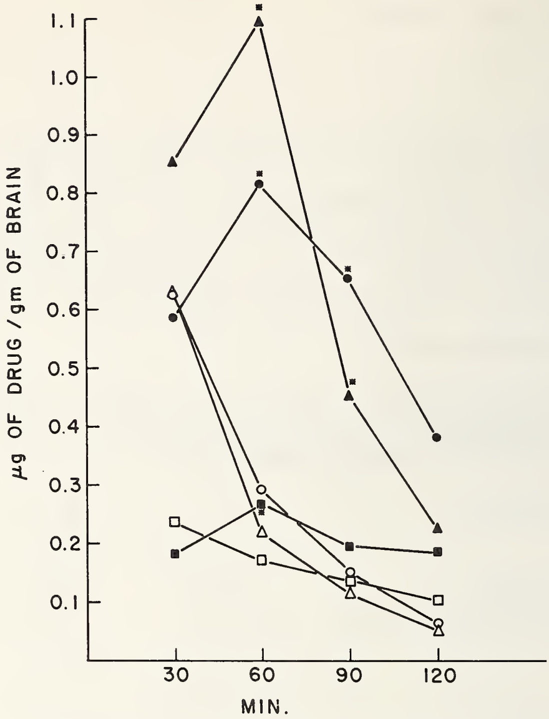


Figure 7 *Levels of diazepam and metabolites in the brain during the 2 hours following oral administration of ^{14}C-diazepam (5mg/kg) to rats treated 30 minutes earlier with water (20 ml/kg) or ethanol (3g/kg, 15% w/v aqueous solution). Each point represents the mean of 5 animals. Controls: diazepam, -△-; monohydroxylated diazepam, —○—; other metabolites,-□-. Ethanol treated: diazepam,-▲- ; mono-hydroxylated diazepam,—●—; other metabolites,-■-.*

CANNABINOIDS AND PENTOBARBITAL

The effect of cannabidiol (CBD), cannabigerol (CBG), cannabinol (CBN), Δ^8-tetrahydrocannabinol (Δ^8-THC), and Δ^9-tetrahydrocannabinol (Δ^9-THC) on the *in vivo* metabolism of ^{14}C-pentobarbital was investigated in rats (2). The cannabinoids (20 mg/kg, ip) were administered 30 min prior to either oral or iv treatment with ^{14}C-pentobarbital. The levels of total radioactivity and of unchanged pentobarbital and metabolites were determined in the blood, liver, brain and urine at various times up to 24 hr after dosing. Figure 8 shows the blood radioactivity profiles obtained after treatment with CBD, CBG, Δ^8-THC or Δ^9-THC and ^{14}C-pentobarbital (30mg/kg, iv). Only CBD had a significant effect on the blood profile. Figure 9 indicates this effect is dose dependent.

SUMMARY

It would appear from these investigations that the metabolism of many drugs may be altered by the presence of ethanol, leading to an enhancement of the pharmacological effects and the increased likelihood of toxic reactions. It has been shown that the clearance of some drugs from the blood of human subjects is retarded by the presence of ethanol (14). Our studies in animals suggest that this is most likely due to an inhibition of drug metabolism by ethanol and very probably, in man as in the rat, such inhibition leads to higher brain levels of the drug and enhanced effects on the target

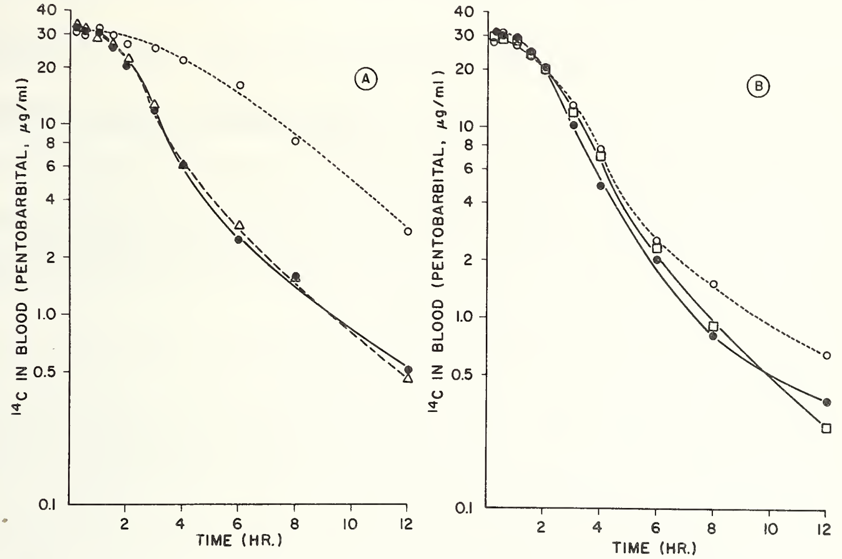


Figure 8 *Blood ^{14}C concentration profiles, expressed as mean±SE of µg/ml of sodiumpentobarbital, obtained from groups of 5 rats treated ip with 20 mg/kg of cannabidiol (CBD, ---0----, cannabigerol (CBG, ---Δ---), Δ^8-tetrahydrocannabinoi (Δ^8-THC,–□–), Δ^9-tetrahydrocannabinol (Δ^9-THC, ---0----, or vehicle (–●–), followed 30 minutes later by ^{14}C-pentobarbital (iv, 30 mg/kg). A-CBD and CBG; B-Δ^8-THC and Δ^9-THC.*

Significant differences: *CBD vs controls-from 1.5 to 12 hours, CBD >controls ($p < 0.01$). Δ^9-THC vs controls – at 0.25 and 1 hour, controls >Δ^9 -THC ($p < 0.05$), at 4 hours Δ^9-THC >controls ($p < 0.05$).*

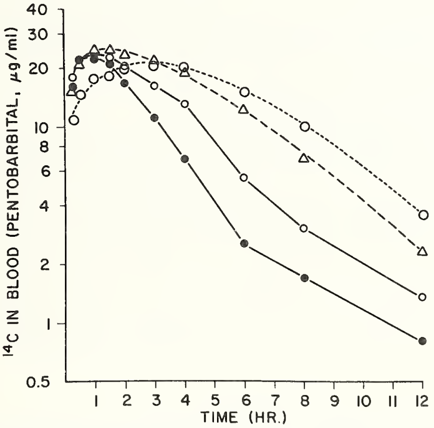


Figure 9 *The dose response effect of cannabidiol (CBD) on blood ^{14}C concentrations, expressed as mean±SE of µg/ml of sodium pentobarbital, obtained from groups of 6 rats treated ip with 5 (-o-), 10 (---Δ----, 20 (---0---- mg/kg of CBD, or vehicle (-●-), followed 30 minutes later by ^{14}C-pentobarbital (po, 30 mg/kg).*

Significant differences: *20 mg/kg vs controls – 1 hour, $p < 0.05$; 3-12 hours, $p < 0.01$. 10 mg/kg vs controls – 1.5 hours, $p < 0.05$; 2-12 hours, $p < 0.01$. 5 mg/kg vs controls – 6 and 12 hours, $p < 0.05$; 2-4 and 8 hours, $p < 0.01$.*

organs, such as the central nervous system. Investigations on the *in vivo* interaction of marihuana components with pentobarbital indicate that non-euphoric effects, due to cannabinoids other than Δ^9-THC, which might lead to impairment of function, are a distinct possibility.

REFERENCES

1. Bogan, J., and Smith, H. Analytical Investigations of Barbiturate Poisoning: Description of Methods and a Survey of Results, *Journal of Forensic Sciences* 7, 37 (1967).
2. Coldwell, B.B., Bailey, K., Paul, C. J. and Anderson, G. Interaction of Cannabinoids with Pentobarbital in Rats, *Toxicology and Applied Pharmacology* 28, in press (1974).
3. Coldwell, B. B., Paul, C. J. and Thomas, B. H. Phenobarbital Metabolism in Ethanol-Intoxicated Rats, *Canadian Journal of Physiology and Pharmacology,* 51, 458 (1973).
4. Coldwell, B. B., Trenholm, H. L., Thomas, B. H. and Charbonneau, S. The Effect of Ethanol on Phenobarbitone and Pentobarbitone Absorption into Rat Blood and Brain, *Journal of Pharmacy and Pharmacology,* 23, 947 (1971).
5. Coldwell, B. B., Wiberg, G. S. and Trenholm, H. L. Some Effects of Ethanol on the Toxicity and Distribution of Barbiturates in Rats, *Canadian Journal of Physiology and Pharmacology.* 48, 254 (1970).
6. Devenyi, P. and Wilson, M. Barbiturate Abuse and Addiction and their Relationship to Alcohol and Alcoholism, *Canadian Medical Association Journal.* 104, 215 (1971).
7. Devenyi, P., and Wilson, M. Abuse of Barbiturates in an Alcohol Population, *Canadian Medical Association Journal.* 104, 219 (1971).
8. Dring, L. G., Smith, R. L. and Williams, R. T. Metabolic Fate of Amphetamine in Man and Other Species, *Biochemical Journal.* 116, 425 (1970).
9. Gardocki, J. F., Schuler, M. E. and Goldstein, L. Reconsideration of the Central Nervous System Pharmacology of Amphetamine. I. Toxicity in Grouped and Isolated Mice, *Toxicology and Applied Pharmacology.* 8, 550 (1966).
10. George, D. J. and Wolf, H. H. Dose Lethality Curves for d-Amphetamine in Isolated and Aggregated Mice, *Life Science* 5, 1583 (1966).
11. Glatt, M. M., The Abuse of Barbiturates in the United Kingdom, *Bulletin on Narcotics* 14, 19 (1962).
12. Gupta, R. C., and Kofoed, J. Toxicological Statistics for Barbiturates, other Sedatives and Tranquillizers in Ontario: A 10-year Survey, *Canadian Medical Association Journal.* 94, 863 (1966).
13. LeDain, G. *Interim Report of the Commission of Enquiry into the Non-Medical Use of Drugs.* Queen's Printer, Ottawa, Canada, 1970.
14. Rubin, E., Gang, H., Misra, P. S. and Lieber, C. S. Inhibition of Drug Metabolism by Acute Ethanol Intoxication. A Hepatic Microsomal Mechanism, *American Journal of Medicine* 49, 801 (1970).
15. Thomas, B. H., Coldwell, B. B., Solomonraj, G., Zeitz W. and Trenholm, H. L. Effect of Ethanol on the Fate of Pentobarbital in the Rat, *Biochemical Pharmacology* 21, 2605 (1972).
16. Wiberg, G. S., Coldwell, B. B. and Trenholm, H. L. Toxicity of Ethanol-Barbiturate Mixtures, *Journal of Pharmacy and Pharmacology* 21, 232 (1969).

The Interaction of Alcohol and Δ^9-Tetrahydrocannabinol in Man: Effects on Psychomotor Skills Related to Driving.

H. M. Franks, G. A. Starmer[1], G. B. Chesher, D. M. Jackson, V. R. Hensley and W. J. Hensley.

A few years ago, we developed a screening protocol for the investigation of the interactive effects of drugs and ethanol on psychomotor performance in human volunteers. A battery of tests was selected and dose-response relationships for ethanol were established. This methodology has been applied to a wide variety of drugs, including those for which there is clinical evidence for synergism (e.g. benzodiazepines) and others which are taken to counteract the inebriant effects of ethanol (e.g., caffeine and fructose).

Δ^9-tetrahydrocannabinol (THC) is considered to be the main psychoactive principle of cannabis sativa and recent investigators (5, 7) have indicated that it exerts a depressant effect on psychomotor functions which are relevant to the driving situation.

Although a number of studies (1, 3, 7) have compared the effects of marijuana and ethanol, relatively little attention seems to have been paid to the effects of the two agents when administered concurrently. In the social context, it is quite apparent that 'mixed' intoxication occurs and, presumably, that driving takes place afterwards.

The present investigation, which is the first of a series, set out to study the effects of a single moderate or 'social' dose of THC upon the impairment induced by a similarly moderate dose of ethanol. It must be emphasized that it was not our purpose to make a qualitative comparison between the effects of the two agents. Rather, since this battery of tests has already been employed in a number of drug-ethanol interaction studies, it was hoped that any THC-induced modifications of the drug would be revealed.

MATERIALS AND METHODS

The Tests

A battery of tests was selected to obtain as broad a coverage as possible of those sensory, motor and intellectual functions which have been reported to be sensitive to the effects of ethanol. In an earlier study, it was established that, under our conditions, all of the tests were sensitive to ethanol in a dose-dependent manner. The tests were as follows:

---

[1] Department of Pharmacology, University of Sydney, Sydney, N.S.W. 2006, Australia.

Standing steadiness. The apparatus consisted of a platform beneath which a displacement transducer is mounted. The actual movement of the platform in the vertical plane is less than 1 micron. Any shift in position creates an electrical pulse (1 kg = 0.385 mV) which is amplified and recorded on a Grass polygraph. An integration of the pulses gives an overall measure of body sway.

The subject stands on the platform facing an oscillograph which can be used to display body sway and to provide a visual cue for corrective movements.

In these experiments, body sway was measured under two conditions: (i) with the eyes open but without the visual cue and (ii) with the eyes closed. The upswing of the pen is integrated, and the integrator epoch or reset time is the measure of body sway. The effect of ethanol is to reduce the epoch time.

Simple and complex reaction time. The reaction timer is the 'Vienna' apparatus designed by Schüfried. The subject sits with his finger poised over the response button and reacts to signals presented to him by pressing the button as quickly as possible. The signals consist of red and white lights and a sound which are presented in programmed sequence.

For measurement of simple reaction time, the subject responds either to a white light or sound. For measurement of complex reaction time, the subject is instructed to respond only to a simultaneous presentation of white light and sound. Complexity arises in that other combinations of stimuli also appear in the sequence. The subjects are allowed to practise to a reasonable plateau of performance before control readings are taken.

The Vienna Determination Apparatus. This apparatus was also designed by Schüfried. It generates a sequence of visual and auditory signals to which the subject responds by pressing the appropriate colour-coded buttons and operating foot pedals.

In this study, the subjects were required to respond to a series of 100 signals presented in random sequence. The number of 'correct' and 'incorrect' responses were recorded. An 'incorrect' response is where the subject either makes an inappropriate response or fails to react altogether. Again, subjects practised to a reasonable plateau of performance before control readings were taken.

Manual dexterity. The number of square wooden beads which the subject was able to thread on a shoe lace in 1 minute was used as an index of manual dexterity. The beads were taken from standard Stanford-Binet kits.

Numerical reasoning. A simple multiplication test with 2-digit multiplicands was used. Parallel forms were prepared from tables of random numbers. A one minute test period was used and two scores were taken: (a) Number of calculations correct and (b) Number of errors.

Perceptual speed. This task consists of checking pairs of numbers ranging from 3-12 digits and marking on an answer sheet whether they were the same or different. A number of equivalent sheets were used, and again, the test period was one minute. Two scores were taken: (a) Number of correct answers and (b) Number of errors.

Analysis of Data

The variation in scores for all tests was high before any treatment was given. Therefore, the results were calculated using an analysis of co-variance based on the method of Cochran and Cox (2). The scores of the control (*i.e.*, pre-dosage) trial of each subject served as a covariate for each of the scores at later time points. When an analysis of co-variance resulted in a significant F-value, t-tests were used to determine which of the treatment differences were significant.

Subjects

The subjects were 12 healthy paid student volunteers of both sexes (8 male and 4 female) aged between 18 and 29 years (mean 21.4 years), with body weights ranging between 59 and 74 kg (mean 61.2 kg). All were non-naive as regards cannabis. Before the first day of the experiment, all subjects were medically examined to ensure that no past or present illness or disability precluded their participation in the experiment.

Drugs

Blood ethanol levels were determined by gas liquid chromatography.

Both THC and ethanol were administered orally. Δ^9 THC, which was generously provided by Dr Monique Braude of NIMH, was dissolved in sesame oil and sealed into capsules. The capsules contained either 5 mg or 2.5 mg of THC. Each subject was given two capsules and the dosage was adjusted to approximately 10 mg/70 kg ($\equiv$ 143 μg/kg) according to the following scale:–

Body weight 50 - 64 kg = 7.5 mg
65 - 79 kg = 10.0 mg

With this series of subjects, the median dose was, in fact, 137 μg/kg (range 117 - 154). Placebo capsules contained only sesame oil.

Ethanol was presented as a beverage containing 20% v/v ethanol in a sugar-free orange squash. Ethanol was omitted from the placebo beverage. Dosage of ethanol was 0.54 g/kg and it was consumed over 20 minutes at a constant rate.

Both the THC and ethanol doses were considered to be in the 'moderate' or 'social' range and were chosen for this initial experiment in order to reduce the possibility of adverse or infinity effects. In previous baseline studies, a dose of 0.54 g/kg of ethanol was found to induce impairment in most of the tests which bordered on significance at the 5% level. The dose of THC was based on data reported by Perez-Reyes *et al* (6) and by Hosko *et al* (4).

A 4 x 4 Latin square design was used and the experiment was conducted over four successive Sundays. Each subject was randomly assigned to one of four groups and received each of the following drug treatments:

1. Ethanol + THC
2. Ethanol + THC placebo
3. Ethanol placebo + THC
4. Ethanol placebo + THC placebo

Procedure

The subjects arrived at the laboratory approximately two hours after consuming a light breakfast. Each subject went through the test battery before receiving any drug treatment. The tests were conducted in separate cubicles to reduce subject/subject interaction and the whole battery could be completed by all subjects in one hour.

After the control run, the subjects received two capsules to provide the required dose of THC or placebo. One hour later, the subjects were given their respective drinks (ethanol or placebo) and requested to consume them over twenty minutes at a constant rate.

Twenty minutes after drinking finished, the subjects went through the test battery again but at this time fingertip blood samples were withdrawn at the mid-point of the sequence. These were used for estimation of blood ethanol levels. The procedure was repeated twice at hourly intervals, *i.e.,* 100 and 160 minutes after the subjects began to drink the ethanol.

RESULTS

Blood Ethanol Concentration

The mean blood ethanol concentration of the subjects receiving both THC and ethanol was significantly higher ($p < 0.05$) than those receiving ethanol alone when tested 40 minutes after drinking began. At later time points, however, although these values were no longer significantly different, there was a trend towards a higher blood ethanol level in the subjects receiving the drug combination (Table I).

TABLE I *The Interaction of Ethanol (0.54 g/kg) and Δ^9-THC (10 mg/kg) Blood Ethanol Concentration (n=12)*

Drug Treatment	Blood Ethanol Concentration (mg/100 ml) at: 40 min.	100 min.	160 min.
Ethanol + THC	73 ± 4	54 ± 3	34 ± 3
Ethanol + Placebo	63 ± 3	50 ± 3	29 ± 3

Standing steadiness. In the 'eyes open' condition (Figure 1), the points represent corrected means and standard error bars are not shown. When the subjects received either ethanol alone or Δ^9-THC alone, they were less steady (shorter epoch time) than when they received the double placebo, but the differences failed to reach significance at any time point (Figure 1). However, the combination of ethanol and Δ^9-THC induced a significant decrease in steadiness compared to either drug alone at 40 minutes and 160 minutes ($p < 0.05$). When compared to the double placebo, the drug combination induced a significant effect throughout the experiment ($p < 0.01$ at 40 minutes and 160 minutes and $p < 0.05$ at 100 minutes). A similar effect occurred with the eyes closed although it was less dramatic.

Reaction time. No trends were apparent for auditing and visual reaction time. Also, no significant effects occurred for complex reaction time but there was a trend for the drug combination to produce a greater decrement than either drug alone at 100 minutes.

Manual dexterity. Neither ethanol nor Δ^9-THC had an effect when given alone. Performance induced by the drug combination, however, was significantly lower than that of the other treatments at 40 minutes ($p < 0.05$).

Numerical reasoning. At the first time point (40 min.), ethanol induced a trend towards impairment. This is consistent with results obtained in previous experiments. Δ^9-THC neither had an effect alone nor modified the ethanol-induced impairment.

At 160 minutes, the drug-ethanol combination induced a significant increase in the number of errors ($p < 0.01$ compared with ethanol; $p < 0.05$ compared with the

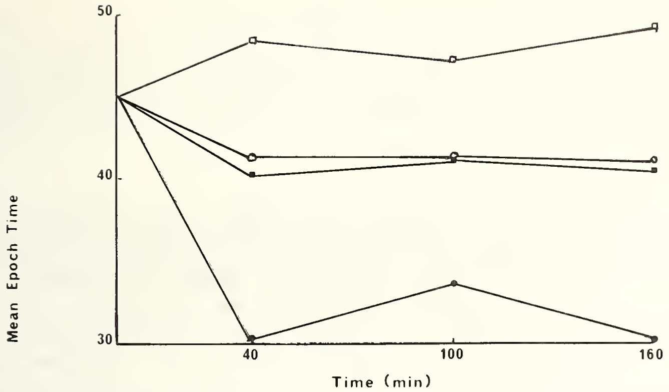


Figure 1 *The interaction between ethanol (0.54 g/kg) and Δ^9-THC (10 mg/70 kg). The effect on standing steadiness (eyes open).*

●	*Ethanol + THC*	○	*Ethanol + placebo*
■	*placebo + THC*	□	*placebo + placebo.*

double placebo). The differences between the ethanol and double placebo groups were not significant, neither were those between the groups receiving ethanol or THC alone.

Perceptual Speed. Although there were no significant differences for correct answer scores there was a trend for the effects of the drug combination to be additive, *i.e.,* the differences from placebo just failed to reach significance.

At 40 minutes, Δ^9-THC induced a significant ($p < 0.05$) increase in the number of errors. This decrement in performance was significant at the 1% level with the drug-ethanol combination. At 160 minutes, the performance of the drug-ethanol treated group was significantly worse than that of the other treatments (Figure 2).

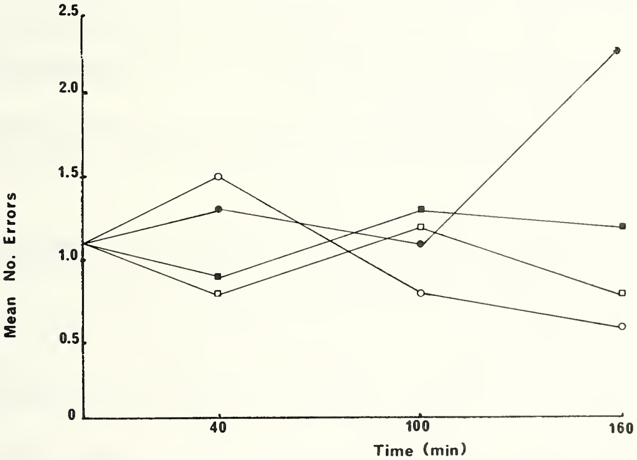


Figure 2 *The interaction between ethanol (0.54 g/kg) and Δ^9-THC (10 mg/70 kg). The effect on errors in the numerical reasoning test.*

●	*Ethanol + THC*	○	*Ethanol + placebo*
■	*placebo + THC*	□	*placebo + placebo.*

The Vienna Determination Apparatus. The effect of ethanol alone on the number of correct responses was not significantly different from that of the double placebo group and in fact there was a non-significant trend for improvement in performance with the Δ^9-THC treatment. However, the drug-ethanol combination did induce a significant decrement at 40 minutes.

As far as incorrect responses are concerned no significant effect occurred with either drug alone at 40 minutes. However, the drug combination produced a significant increase in the number of errors made. At 160 minutes, Δ^9-THC either alone or in combination with ethanol induced a significant increase in the number of errors.

DISCUSSION

Administration of THC in sesame oil should, according to Perez-Reyes *et al* (6), have allowed for adequate gastrointestinal absorption within one hour and plasma levels would be expected to be maintained throughout the experimental period. The blood ethanol levels in the group receiving ethanol alone were essentially similar to those observed in other groups of subjects who received a dose of 0.54 g/kg under the same conditions. The group which received both ethanol and THC, however, had higher blood ethanol levels than that which received ethanol alone, the difference being significant at 40 minutes. We consider this to be noteworthy but that caution must be exercised before a valid interpretation can be made. Further studies are to be conducted to determine whether a metabolic interaction really exists.

At the dose level employed, ethanol alone did not induce significant decrements in performance in any of the tests. This is again consistent with previous experience of the effects of a dose of 0.54 g/kg.

Similarly, THC alone was without significant effect in most of the tests. However, there was a slight increase in the number of errors made in the perceptual speed and Vienna Determination Apparatus tests.

A combination of ethanol and THC did produce changes in several of the tests which were significantly different, not only from the placebo group results but also from those of the groups receiving either drug alone.

Also of importance and interest was the increase in errors, but not in performance, in the numerical reasoning and perceptual speed tests and also on the Vienna Determination Apparatus. We have never before encountered such an increase in errors in all three tests in one study.

In conclusion, the results indicate that an interaction between ethanol and THC was apparent in the tests employed and that this interaction was at least additive.

REFERENCES

1. Cappel, H., Webster, C. D., Herring, B. S. and Ginsberg, R., Alcohol and Marihuana: A Comparison of Effects on a Temporally Controlled Operant in Humans. *Journal of Pharmacology and Experimental Therapeutics* 182, 195-203 (1972).

2. Cochran, W. G. and Cox, G. M., In *Experimental Designs,* Second edition, John Wiley and Sons, New York, 1957.

3. Crancer, A., Dille, J. M., Delay, J. C., Wallace, J. E. and Haykin, M.D., Comparison of the Effects of Marihuana and Alcohol on Simulated Driving Performance. *Science* 164, 851-854 (1969).

3. Hosko, M. J., Kochar, M. S. and Wang, R.I.H., Effects of Orally Administered Delta-9-tetrahydrocannabinol in Man. *Clinical Pharmacology and Therapeutics* 14, 344-352 (1973).

5. Kielholz, P., Hobi, V., Laedwig, D., Meest, P. and Richter, R., An Experimental Investigation about the Effects of Cannabis on Car Driving Behaviour. *Pharmakopsychiatric Neuro-psychopharmakologie,* 6, 91-103 (1973).

6. Perez-Reyes, M., Lipton, M. A., Timmons, M. C., Wall, M. E., Brine, D. and Davis, K. H., Pharmacology of Orally Administered Δ^9-tetrahydrocannabinol. *Clinical Pharmacology and Therapeutics* 14, 48-55 (1973).

7. Rafaelson, O. J., Bech, P., Christiansen, J., Christrup, H., Nyboe, T. and Rafaelson, L., Cannabis and Alcohol: Effects on Simulated Car Driving. *Science,* 179, 920-923 (1973).

SECTION III

Analytical Aspects

Program Committee	*Head:* DOUGLAS M. LUCAS KURT M. DUBOWSKI GOTTFRIED MACHATA

Reliability and Significance of Results of Alcohol and Drug Analyses

A. S. Curry[1]

Before any discussion can take place on the reliability and significance of results it is necessary to define what is being measured. The identification procedures which are used to characterize a drug that has been extracted from a body fluid must be considered.

METHODS AND PROBLEMS OF IDENTIFICATION

Two main methods are employed extensively in most laboratories. Firstly, there are those based on spectroscopic methods, and secondly, those based on chromatographic parameters. Some laboratories now use a combination of the two.

Light Absorption Methods

The use of the light absorption by compounds, for identification purposes, can probably be best illustrated by the differentiation of lager from beer by colour. The scientist has extended this simple visual inspection into more sophisticated procedures in which the light that may be used is in any part of the spectrum from ultra-violet through to the visible and infra red. Instead of a simple colour seen by the eye, it is possible with present day machines to obtain a visual tracing that shows the way in which the substance is absorbing the light over the wavelengths that are being measured. It is tempting to say that, if the substance has a particular spectrum and the sample extracted from a body fluid exhibits the same spectrum, identification has been achieved. The next few examples will show however, that this can be an erroneous conclusion. In the ultra-violet region, the spectra of all the 5:5' barbiturates are identical, notwithstanding the fact that structures vary considerably from member to member of the class. Thus, it is not possible to distinguish by ultra-violet spectroscopy the drug barbital, which may be given in doses of 500 mg from that of secobarbital which is given in doses of 50 mg. That the analyst has found a barbiturate will not be disputed, but in subsequent interpretation it is vital to know which particular barbiturate is involved. A similar example is ephedrine and methyl ephedrine hydrochloride (Figure 1).

---

[1] Home Office Central Research Establishment, Aldermaston, Reading, U.K.

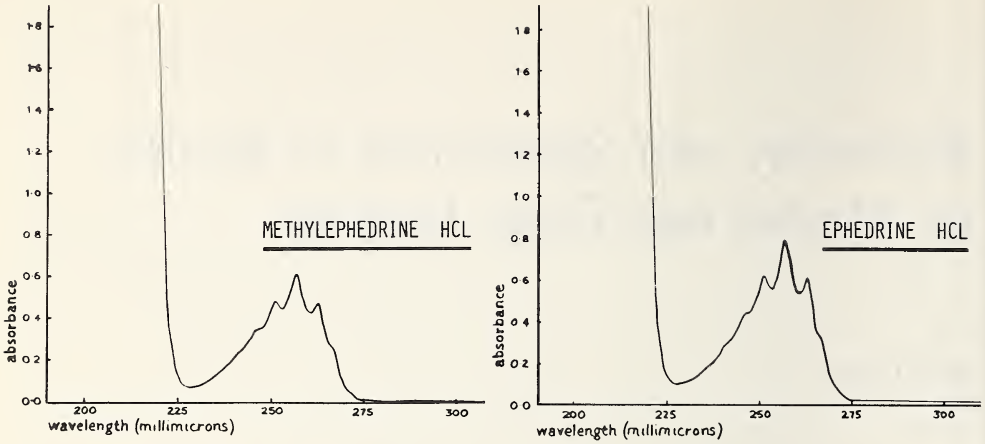


Figure 1 *A comparison of ephedrine and methylephedrine hydrochlorides.*

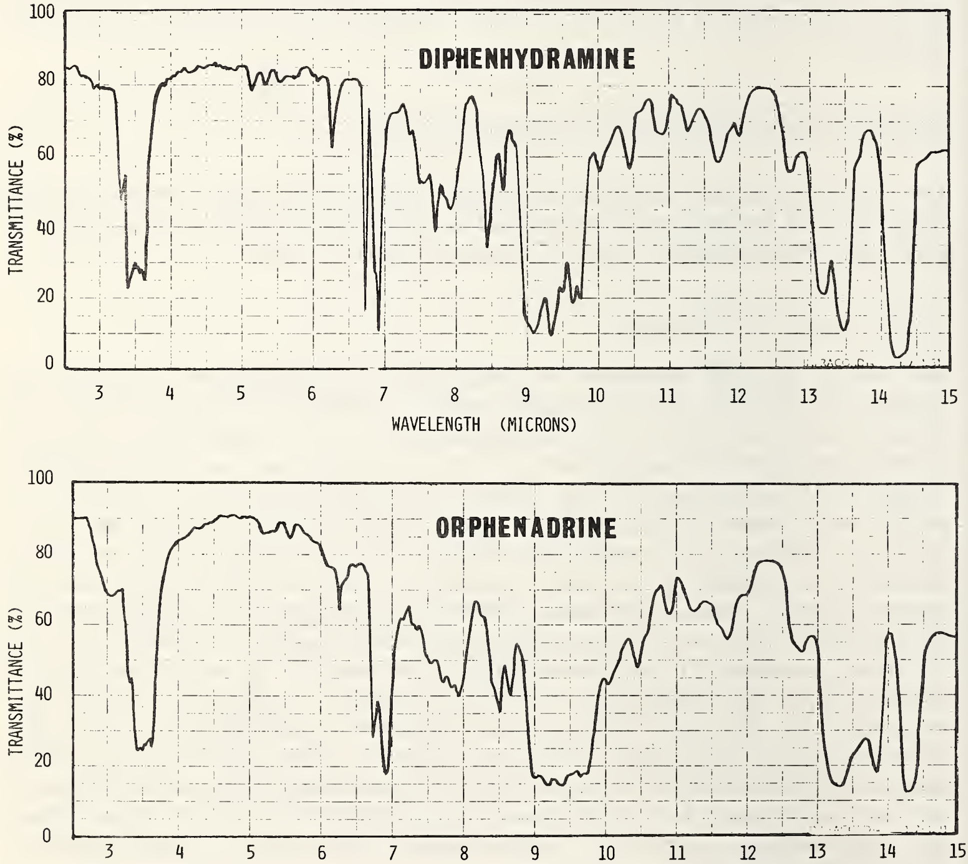
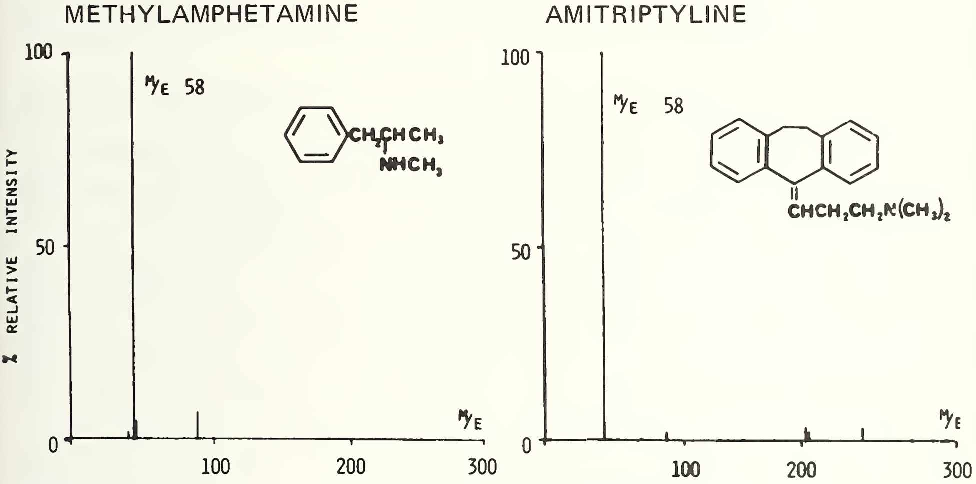


Figure 2 *Comparison of diphenhydramine and orphenadrine.*

The infra red part of the spectrum has a much higher degree of specificity – indeed, it is conventional to refer to parts of the spectrum as the 'fingerprint region'. As well as ephedrine and methyl ephedrine hydrochloride, diphenhydramine and orphenadrine, which differ by only a methyl group, provide another such case where confusion can occur. Diphenhydramine is an antihistamine; orphenadrine is a parasympatholytic drug! Their infra red spectra are shown in Figure 2 and illustrate how critical inspection is necessary.

Mass Spectroscopy

In the last two or three years considerable attention has been focussed on the use of mass spectroscopy for the absolute identification of drugs. In this technique the drug sample is bombarded with electrons and fragments in such a way that the characteristic picture obtained very often enables one to reconstruct the jig-saw puzzle to produce a perfect identification of the original molecules. However, if low resolution mass spectrometry is employed similar molecules can fragment in similar ways, for example, methylamphetamine and amitriptyline, as shown in Figure 3. This again demonstrates that critical appraisal is necessary of any technique that claims to be a universal panacea.


METHYLAMPHETAMINE

AMITRIPTYLINE

Figure 3 *Comparison of methylamphetamine and amitriptyline.*

Chromatography

One cannot overstate the dramatic impact that chromatographic methods have had in analytical chemistry in the last twenty years. Chromatography using paper, thin layer supports, in the gas phase and on columns using high pressures, have enabled separations to be achieved in previously unbelievably small quantities; much of our present day technology would be impossible without this technique. It must be stressed, however, that it is a method of separation. Although selective detectors and spray reagents can be used, it must not be forgotten that essentially all one achieves is a tracing, be it by colour or electronic pen. Some colours can be highly specific but if the electronic pen is used, all one really knows is that 'something' is behaving as a positive reaction at a particular place on the chromatogram. Because of their simplicity, the lower molecular weight substances, such as carbon monoxide and alcohol, can be reliably identified by chromatographic procedures if the correct columns are used, but when the much higher molecular weights are encountered, for example, drugs, erroneous conclusions may be drawn.

Three examples serve to illustrate this point concerning reliable and erroneous conclusions. The first involves the thin layer examination of urine for cannabis metabolism products. At one stage, it was believed in our laboratory that an extremely good method of detection had been discovered; however, when many urines from persons who had not smoked cannabis was obtained, it was discovered that the occasional person could produce an apparent positive reaction. The compound responsible for the similar reaction was not finally established but it was thought that it came from a particular component of food. This phenomenon is commonly found in biochemistry where, for example, the eating of bananas can upset the determinations of 5-hydroxyindole acetic acid.

The second example concerns that of a gas chromatographic procedure for the identification of methylamphetamine. In a series in which the method was being tested, it was discovered, to the horror of the scientist, that her boss was giving a positive reaction. Only when the 'apparent' methylamphetamine was subjected to derivative formation techniques was it discovered that some people did give a positive gas chromatographic result on a particular column indicating the presence of methylamphetamine, but that in fact the offending compound is a component of normal urine.

The third example concerns a case reported in the literature (9) in which gas chromatography was used in a case of suspected overdose of glutethimide: a peak was obtained but reinvestigation the following day showed that it came from the intake of a organophosphorous insecticide. These examples which could have had far reaching consequences illustrate my point that for high molecular weight compounds, a single chromatographic parameter is not conclusive evidence of identification.

The need to subject all new techniques that rely on a single identification parameter, to far searching exercises with a large number of normal controls to test the alleged specificity of the method, was emphasized by some work done at the Central Research Establishment on the automated analysis of urine for morphine (2). The detection procedure consisted of oxidising the extracted morphine to pseudo-morphine and measuring the characteristic fluorescent spectrum. In an analysis of urine from 500 individuals who were not thought to be on drugs, one was discovered which gave a positive reaction. Further analyses of this urine revealed the presence of an alkaloid from ipecacuanha called caephaline; it has the tertiary amine and phenolic groups similar to morphine and so was coextracted with it and interfered in the fluorometric determination. When a similar method was tried out on New York addicts it was also discovered that large doses of quinine gave a metabolite of quinine, which interfered with the method. It should be mentioned, that until these large scale surveys were done, the analytical method was thought to have very high specificity.

A single chromatographic parameter or a single color test is clearly insufficient for identification, but many scientists believe that if they use several chromatographic parameters the probability of an unique identification is vastly increased. Certain work from the Central Research Establishment has indicated that this is not necessarily true (5, 6). It has been found that a very high degree of correlation may exist in both thin layer and gas chromatographic separations and that a great deal of work attempting to positively identify drugs has been completely wasted time. At the Central Research

Establishment work is going on concerning the selection of systems which are *not* correlated and hence *do* provide more identification.

Another of the methods used for improving the probability of the correct identification is to react the extracted drug with a chemical that will convert it to a derivative which is then examined by gas chromatography. In a large number of cases studies have shown that on non-polar columns, as far as basic drugs are concerned, the retention time of the derivative is highly correlated with the unchanged drugs. Hence the only amount of information one gets from this procedure is that the compound will form a derivative. I appreciate that these interpretations are open to other statistical evaluations but it is probable that in many cases identification is incorrect.

Identification of Alcohol

Identification of alcohol has received much attention which I will not repeat here except to say that the deficiencies of dichromate oxidations and enzymatic methods are tied in completely with the integrity of the sample. In all cases, one must consider the other compounds that could possibly be present in the concentrations that have been found. Methods of identification that provide alternatives to molecular structure determination depend on accepting techniques which may be interfered with by other compounds; but it must be ensured that those other compounds are not present. Given these exclusion criteria, the well tried methods of identification for alcohol are fully satisfactory.

Immunological Procedures

Another technique of identification which is rapidly gaining ground is that involving immunological procedures. In these techniques the drug under investigation is bound to a protein and injected in to an animal. The animal does not like the injection, his body rejects by producing antibodies which can be separated and used as a detection for the original drug. In the vast majority of immunological procedures, however, cross reactions can occur with drugs of a similar type, for example, codeine and morphine. Thus, a great social injustice could follow if a laboratory result was positive for morphine but did not point out to uninformed authorities that this also could have come from codeine ingestion.

The inter-relationships and problems of interpretation are also demonstrated by the differing plasma/red cell ratios in the cardiac glycoside series of drugs. Also, the interpretation of results of carbon monoxide assays are bedevilled by differing ways of expressing the results.

PROBLEMS IN QUANTITATION

The subject of how much drug is present in a particular biological fluid must now be considered. The most common procedure is to first isolate the drug and then employ the preferential solubility of the drug in an organic solvent; it is customary to shake the blood or urine with chloroform or ether, or a variety of solvents to separate the drug from all the normal biological materials that are present in the body fluid. Clearly, the differing solvents co-extract differing amounts of metabolites. Evaporation of the solvent coupled with selective use of acids and bases can provide a reasonably pure extract which can then be investigated by chromatography.

It is necessary at this stage to turn to the question of quantities of drug involved and volumes of solvent employed. In the case of most drugs it is necessary to measure quantities of the order of a few micrograms, *i.e.,* 1 millionth of a gram. In the case of very active drugs it may be necessary to go down to a nanogram, *i.e.* 10^{-9}. To put this into perspective one must visualize multiplying a gram by one thousand million rather than dividing it by the same amount. The multiplication gives a figure of 200,000 five-ton elephants. One can see from this analogy that the quantities which the analyst regularly measures are extremely small. The volumes of solvents employed may be upwards of 10 ml, that is to say, ten thousand million times the quantity of drug which is being analysed. The solvent, or any trace impurity in it, may react with the drug. For example, chloroform or impurities in it can react with methadone. This is an area that has been very largely neglected up to now but we are due for some surprises in the next few years. It is being rapidly realized that tertiary amines are very prone to attack by halogenated solvents.

The next fact for our consideration is that body fluids do not behave in the same way as water solutions in extraction procedures. For example, from aqueous alkaline solution the phenothiazines such as chlorpromazine are extracted with either ether or chloroform with a 100% recovery. If a blood sample is broken down with concentrated hydrochloric acid, the subsequent extraction of the phenothiazines with chloroform gives a nil recovery whereas ether produces a 100% recovery, if an ultra violet method of assay is used. This serves as an example of the extreme care one must exercise in considering quantitation, for clearly the final results depend on the efficiency of the extraction and in making sure that it does not affect the drug. One way around this problem is to add to the blood sample a known amount of a substance which is chemically very similar to the drug in which one is interested. Any inefficiencies in extraction or imperfections in measurement are then paralleled with the substance that has been added and so better quantitation can be achieved. This is called the internal standard method. This procedure, which has become widely used in analytical chemistry in the last few years, nevertheless contains potential imperfections of technique which have not been fully recognized. One still commonly sees internal standards being added which are chemically dissimilar from the drug under investigation. When this happens, reactions, or potential reactions, between the internal standard and the solvent will not parallel any reactions between the drug and the organic solvent and completely erroneous conclusions as to quantitation may be drawn. Even chemicals used as plasticisers have been added as an internal standard at too late a stage in the analyses – one error adding to another.

Gas chromatography has been the major area in which internal standards have been used and a direct tracing comparison can be obtained giving a very high degree of precision. Very often the internal standard is used too late in the analyses. It is necessary in such cases to measure the area under the curves and this is usually done electronically. However, these instruments are capable of being set to a cut-off point so that the small amount of noise at the bottom of the trace is excluded. However, if the instrument is so that, for example, the lower 5% of the curve is excluded from the integration, it can be seen that a different proportion of the total integrator count of the drug is excluded and hence a non-linear calibration curve is obtained. Thus the internal standard is giving a constant value and the drug calibration is made with different quantities. A fact that is sometimes not recognized and as a consequence the precision of the method is reduced.

ACCURACY AND PRECISION

The analyst must satisfy himself that what he is measuring is known and must have confidence that how he is measuring it is correct. How is he to ensure the reliability of his measuring procedure? There are two definitions which must be introduced at this stage, these are, firstly, the accuracy of the method, and secondly, the precision of the method. By accuracy is meant "is one getting the right answer?"; and by precision, "how well can one reproduce the results that are obtained?" An accurate method may not be precise, and a highly precise method may not be accurate (Figure 4). Accuracy has to be ensured by comparing exact and controlled solutions to which known amounts of drugs have been added with the sample under investigation. It is essential that the controls should straddle the unknown determination. To measure precision it is necessary to analyse the same solution many times to see the spread of results that is obtained. Generally speaking, the greater the number of determinations one does on a sample the more precisely one can state the probable result. Analysts take great care to produce an accurate result and use 'quality control' or 'performance evaluation' experiments. These have been conducted in various countries. In Europe, Switzerland has published results from circulating blood samples containing ethanol between laboratories. Also, in Sweden a great effort goes into measuring the accuracy and precision of the methods employed. In England, the Central Research Establishment takes the responsibility of circulating blood samples that are unknown to the analyst between the national forensic science laboratories and a constant monitoring watch is kept on the two problems of accuracy and precision.

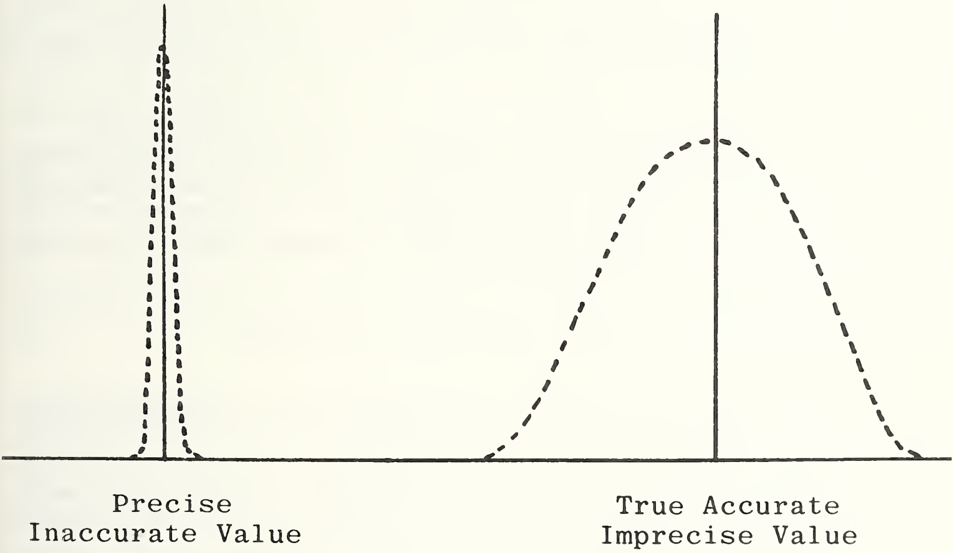


Figure 4 *Comparison of a "precise but inaccurate" value and a "accurate but imprecise" value.*

Pioneering work has been done in North America in relation to quality control. There has, however, been a noticeable lack of *international* quality control. It should be noted, however, that American, Canadian and British authorities involved in aircraft crash investigations have circulated blood samples for carbon monoxide determination, but other international schemes in toxicology have not come to my notice.

Keeping the Sample Constant

Analytical techniques must have a high degree of specificity to exclude potential interfering compounds. In the case of alcohol this is essential. Many cases have occurred in which isopropanol has been found in the course of a gas chromatographic examination of a blood sample. This has eventually been traced to the use of a disinfectant on the arm of the subject by the doctor before he took the blood sample. Usually impurities can be readily recognized; in these cases however, if a single enzymatic method was being used then interference would clearly be possible. In the above mentioned cases the doctors did not realize that the disinfectant contained isopropanol, without careful laboratory monitoring errors could have been introduced.

Clearly, in the case of drugs, external contamination should not be a problem but sometimes the use of plastic containers can produce compounds from the plasticers which can cause analytical difficulty. In the case of alcohol there are certain biological mechanisms that can affect concentration of alcohol found in the blood at the time of analysis (compared to the time of taking the sample) if precautions are not taken. Bacteria can metabolize alcohol and can also produce and destroy carbon monoxide and cyanide in blood samples. The diabetic who is excreting sugar in his urine provides a substrate which if acted on by yeast in the absence of a good preservative can produce alcohol. Thus one must be constantly aware of the artifact situation in relation to this particular drug.

Recently an alcohol oxidase which is not inhibited by fluoride was discovered by workers at the Central Research Establishment. This alcohol oxidase by an oxyhaemoglobin intermediate, produces a loss of alcohol of about 2mg/100 ml blood per week and may account for some of the discrepancies observed between the 'official' analysis and the eventual analysis of blood samples by defence analysts (8). Steps are being taken to incorporate a reductant in the containers supplied for the taking of blood in the U.K.

In the case of drugs it must be recognized that some are highly unstable. For example, a sample of LSD in urine, if left on the laboratory bench in sunlight, disappears completely within two days. Also, there are esterases in some urine which will decompose compounds like succinyl choline within a few minutes; all of which emphasises the need for studies using large numbers of samples when perfect systems suitable for legal use are to be introduced.

THE DIFFICULTY WITH DRUGS AS OPPOSED TO ALCOHOL

The main point of the above section is that the analyst must be satisfied that what he is measuring in his laboratory directly represents the state of affairs in the sample when it was taken. The accuracy and precision that can be obtained in any particular laboratory depend on the substance to be analyzed, the techniques used, and the in-built tests that are performed in a particular laboratory. In the case of alcohol, 100% accuracy can be achieved and precisions of 1 to 2% can be maintained in a national system.

In the case of drugs, however, the same conditions do not apply. It must be recognized that the analysis for drugs in urine and blood is in general a highly complex procedure, more difficult and complex than those exercised for alcohol. In addition, in toxicological cases, it is not usually essential to achieve a high degree of precision. This is because the question that is being asked of the toxicologist is whether the victim has taken one dose, ten doses or 100 doses. Variability of 1% in these conditions is therefore of no consequence. However, the automated procedures developed at the Central Research Establishment in which every sample is treated identically can give results with a precision of 2%. In fact, very little quality control work has been done in the drug field as far as precision is concerned.

The Size of The Dose and Its Effect

In the case of drugs the question must be asked "why is an analysis necessary?" There are perhaps two aims, firstly, to determine the dose that was given or taken, and secondly to determine the probable effect that the dose of a particular drug had. In the case of the determination of the concentration of alcohol in blood it has been the practice for many years to use the well-known Widmark factor to indicate to the courts the probable minimum intake of alcohol by the accused. In many countries this has been superseded by giving to the court the concentration of alcohol in the blood and drawing attention to the statistical significance of this in relation to the effect on the person. It is not possible to give a figure for the total amount of alcohol consumed but merely for the probable amount that was in the body at the time the sample was taken. This has been possible because alcohol behaves like water in the body and we have a great deal of biochemical knowledge concerning the distribution of water as well as how the kidneys convert the blood into urine. Unfortunately the same is not true for the vast majority of drugs.

A drug that is swallowed may be in any one of a number of pharmaceutically available forms. The rate at which the drug may be released into the stomach or the small intestines can vary the rate of absorption dramatically. We all know that whisky is far more rapidly absorbed than beer, but in non-alcoholic drugs active material may be bound onto resin or tightly compressed into a slow dissolving tablet so that its absorption is very slow indeed.

There have been a very large number of papers in the last year or two on the "bioavailability" of the heart drug, digoxin. Investigation showed that a change in formulation resulted in different blood levels even when the dose was the same. Clearly the chemical nature of the drug can also affect its rate of transference from the alimentary tract into the systemic circulation. It is clear at the outset, therefore, that *even if* the blood level can be assumed to measure the total amount in systemic circulation there is no easy formula to convert this figure into the probable ingested dose.

'Types of Blood'

Another problem is that the blood in the arteries is not biochemically the same as that in the veins, and distinct differences can be found between blood samples taken from different parts of the body. In the dynamic absorption of a drug, and similarly in the sudden release of biogenic amines from a tumour, large differences in the concentration of a drug or amine at a particular site compared to other sites may be found. In death cases from barbiturate overdose it has been observed (3) that considerable variations may be found in, for example, the portal vein blood and the peripheral venous blood. This is understable since a high concentration is absorbed from the gastro-intestinal tract and as this blood passes through the heart, to be distributed to the various tissues of the body, it is diluted by the circulating blood. Sampling at different parts of the body therefore reveals different concentrations. In the case of alcohol, differences are noted even between the left arm, the right arm and the legs (4, 7). This is of minor significance in a medico-legal sense but necessary to remember when interpreting the results of analyses.

BAC From Urine Concentration

Urine is produced by the filtration of blood through kidneys. The kidney acts as a means of clearing waste products from the body. Only a minute amount of urine is produced from the blood that passes through the kidneys. In general, the kidney protects the body from the loss of proteins and other essential chemicals either by not letting them pass through the filtration mechanism or by reabsorbing them when the material is in the process of elimination. Glucose is an essential nutrient and only when large amounts are produced in disease does this nutrient pass into the urine. In the case of other compounds it is essential that all of the waste products be eliminated so that a very high degree of transference occurs from the blood into the urine. Therefore, there can be passive elimination or active secretion or complete suppression of materials passing from the blood into the urine. All these phenomena may be seen in the case of drugs. I wish to use two examples to illustrate that where it may be relatively easy to predict a blood concentration from the urine concentration and where it may be impossible. The examples I choose are those of alcohol and amphetamine.

Easy prediction. It has been shown that alcohol behaves in the same way as water so far as the kidneys are concerned. It is also clear that in breath analysis, calculations can be made, based on the volatility of alcohol and how it passes from the lungs to the breath. Thus in the case of both breath and urine, the concentration of the alcohol in the blood can be reasonably estimated.

Difficult prediction. In the case of amphetamine, however, the urinary secretion is highly dependent on the degree of acidity or alkalinity of the urine. A change of the acidity in the urine can alter the concentration of the drug in the urine by a factor of a hundred. This is because the passage of the drug in the kidney into the urine can be radically altered by a change in the degree of the acidity of the urine. The more acid in the urine, the more amphetamine is secreted.

The effect of acidity is one that is particularly pertinent in the case of drugs. It is a primary aim of clinicians treating the poisoned patient to remove as much drug from the body as possible. Yet, it is seldom thought worthwhile to increase the secretion of urine forcibly so that the drug can be effectively eliminated. It is well known in the field of sports-medicine for example, that the effects of amphetamine can be prolonged by simultaneously taking sodium bicarbonate with the result that the urine is made alkaline with a corresponding reduction in urinary excretion. If ammonium chloride is taken at the same time as the amphetamine then the drug has a diminished effect because it is being more actively eliminated. This is not a contradiction in terms, as a higher concentration in the urine leads to a lower blood level. However, in the vast majority of cases very little is known concerning the way in which drugs pass from the blood into the urine. Complications from selective absorption into the systemic circulation are therefore compounded by a lack of knowledge of the way in which the kidney removes them from the blood.

Other Complications with Drug Analysis

So far, excepting the distinction between arterial and venous blood, it has been implied that some drugs will pass from the blood into the urine. It has also been noted that proteins will not pass through the kidney. Some drugs are bound in varying degrees to protein and the 'protein bound fraction' is therefore not eliminated. It is difficult to measure this factor routinely or to know if the free drug or the bound drug, or indeed if both, are significant when measuring the effect of the drug. Thus, in the vast majority of cases it is not possible to deduce the probable blood concentration from a urinary concentration. Other problems such as those resulting from changes in the drug by metabolism, that is, alteration in the drug that makes it more easy to eliminate from the body by the kidneys, can occur. This usually goes on in the liver. In many cases the drug is transformed by the body into a more active drug and this introduces further complications. The question has to be put as to whether one should measure the drug, its metabolites (which may number many tens of compounds) or possibly a combination of all, if one is to try to deduce the probable effect.

THE SIZE OF THE DOSAGE AND ITS EFFECT

I would now like to move on to the idea that the higher the concentration of drug in the blood, the more likely it is to affect the person. In many cases of drug involvement the idea that double the dose produces double the effect is not correct. For example, Swedish workers have shown that in the case of nortriptyline – a common anti-depressant, steady state plasma levels vary tenfold to thirtyfold between individuals on the same mg per kilo dose (1). What must be measured is the concentration of drug at its site of action – and this may be anywhere in the body. The blood is merely a transport mechanism carrying the drug from A to B. This is a dynamic process because while the drug goes into B it also goes on to C; it may be stored at C and then pass on to D. B, C, and D may be the liver, the brain, the gall bladder, the kidneys, or indeed a very small portion of the brain. There may be massive amounts of drug in the body and yet almost undetectable amounts in the blood because the drug has been localized in one particular centre. For example, in the case of heroin, metabolism occurs very rapidly in the liver, the drug is deacetylated to morphine, and the blood carries this around to the active centres. At the active centres the drug is absorbed and removed from the circulation. As morphine passes through the liver it is conjugated to the glucuronide and this passes very efficiently from the kidneys to the urine. For many years it was extremely easy to detect morphine glucuronide in the urine but extremely difficult to detect morphine in the blood. Even in persons fatally intoxicated with morphine the concentrations have been so low in the blood that on many occasions it has been undetectable. Notwithstanding the fact that many other drugs taken in the same dose produced easily measurable concentrations in the blood, morphine escaped detection. Even today the difficulties are immense: special techniques must be used for any success. Because the blood is acting simply as a transport mechanism and the site of action selectively absorbs the drug from the blood, it is clear that blood concentrations do not in all cases, indeed in the vast majority of cases, present a simple correlation relating level to effect.

Thus, in the clinical interpretation of the effect of a drug on a person, three separate relationships may be considered. Firstly, there is the relationship between dose and effect; generally speaking, a small dose will not kill the person; a large dose will. Secondly, there is the relationship between the dose and the level of the drug in the blood. This is a relationship which applies in some cases but not in others. Finally, there is the relationship between the level of drug in the blood and the effect; again this relationship does not hold in a large number of cases. Because most of these relations hold for alcohol it is very tempting for the layman or the lawyer to believe that the same criteria hold for other drugs but it must be emphasized that generally that is not so.

DRUGS, ALCOHOL AND TRAFFIC SAFETY

Scientists and doctors have produced statistical evidence in relation to the absorption, distribution, systemic circulation and excretion of alcohol, which allows valid conclusions to be drawn and allows those responsible for traffic safety to take effective action. As far as drugs are concerned the picture is highly complex and each individual drug must be considered separately. It is necessary to show that there is some relationship between concentrations of a particular drug in body fluids and accident involvement. Whether one measures blood or urine concentrations, there are analytical difficulties which are far more intense than those met in the case of alcohol and clearly breath analyses are out of the question. How the body deals with drugs must be viewed not as an overall concept but each drug must be looked at individually. At this time there are several thousand drugs available to the man in the street either over the counter or by legal medical prescription. It will be necessary to undertake studies relating accidents to a particular drug in the same way as was done for alcohol. Samples of urine or blood will have to be taken from motorists involved in an accident and compared to those of a similar motorist passing on the same road at the same time. Only if this is done will a statistical estimation be possible as to whether a drug causes an accident.

Automated Procedures

It may be necessary for many thousands of samples to be analysed before this correlation or lack of correlation can be found. Unless automated procedures are used, to which reference has been made above, the analytical effort is probably prohibitive at the present time. Automatic procedures if suitably selected provide a high degree of both specificity and precision. They provide the technology for investigating this problem of causal relationship. It is possible for one machine to analyse several hundred samples a day (for example the amphetamines, barbiturates, methaqualone and morphine derivatives) with a high degree of specificity and precision. As yet this is not possible for tranquillizers of anti-depressants.

Social Requirements and Technical Capability

Social requirements are still governed by technical capability. For example, there has been a great deal of concern on the effect of cannabis on driving. However, the analytical methodology as far as blood levels are concerned is not generally available to do the necessary tests. Questions of absorption, metabolism, distribution and excretion add to the complications.

Before a drug law is socially acceptable it must be shown that the particular drug has an effect on the accident rate. If a causal relationship is shown it may be necessary to introduce a total ban on the drug's appearance in body fluids in drivers. In many cases it will not be possible to relate a urinary excretion to a blood level nor to relate the blood level to the dose or the effect. The body is a highly complex dynamic factory and the analogy of drugs with alcohol just does not hold. To put this into layman's terms, one does not excrete a T-bone steak in the urine. One cannot tell by the concentration of protein in the blood whether one has had a T-bone steak or a rump steak. Indeed it is not possible to say whether one has had a steak at all and a similar situation occurs for a number of drugs.

CONCLUSION

It is not as easy to give clear answers to questions concerning quantitation and effects of drugs, as it is with alcohol. Even with alcohol there are still some problems. The situation is thus depressing for those concerned with the possible influence of drugs on accidents, as well as for legislators. However, there is a tremendous amount of work going on in pharmocodynamics and pharmacology and toxicological analysts are producing techniques which augur well for the future.

REFERENCES

1. Balazar, A., Asberg, M., and Tuck, D., Relationship between Steady State Plasma Concentrations of Nortriptyline and Some of its Pharmacological Effects. In *Biological Effects of Drugs in Relation to their Plasma Concentrations,* Davies, D. S., and Prichard, B.N.C. (Eds.), MacMillan Press, 1973.
2. Blackmore, D. J., Curry, A. S., Hayes, T. S., and Rutter, E. R., Automated Analyses for Drugs in Urine, *Clinical Chemistry* 17, 896 (1971).
3. Gee, D. J., Dalley, R. A., Green, M. A., and Perkin, L. A., Post Mortem Diagnosis of Barbiturate Poisoning. In *Forensic Toxicology*, Ballantyne, B. (Ed.), John Wright and Sons, Bristol, U.K., 1974.
4. McCallum, N.E.W., and Scroggie, J. G., Some Aspects of Alcohol in Body Fluids: Pt. III, Study of Alcohol in Blood in Dirrerent Parts of the Body, *Medical Journal of Australia* 47, 1031 (1960).
5. Moffat, A. M., and Smalldon, K. W., Optimum Use of Paper, Thin Layer and Gas-liquid Chromatography for the Identification of Basic Drugs. II. Paper and Thin Layer Chromatography, *Journal Chromatography* 90, 9 (1974).
6. Moffat, A. M., A. H., and Smalldon, K. W., III. Gas-liquid Chromatography, *Journal of Chromatography*, 90, 19 (1974).
7. Neave, W., Koops, E., Audrlicky, I., and Brinkmann, B., Venovenose Differenzen der Blutalkoholkonzentration nach Sturztrunk, *Bultakol* 8, 451 (1971).
8. Smalldon, K. W., Ethanol Oxidation by Human Erythrocytes, *Nature* 245, 266 (1973).
9. Sine, H. E., McKenna, M. J., Rejent, T. A., and Murray, M. H., Emergency Gas-Liquid Chromatography Determination of Barbiturates and Glutethimide in Serum, *Clinical Chemistry* 16, 587 (1970).

Recent Developments in Breath-Alcohol Analysis

Kurt M. Dubowski[1]

This review of recent developments in breath-alcohol analysis covers the period since the 5th International Conference on Alcohol and Traffic Safety at Freiburg, Germany in September 1969. It is concerned chiefly with the intervening developments in apparatus and devices for breath-alcohol analysis, and with certain closely related matters, such as promulgation of apparatus standards. For practical reasons, the scope of this review is limited to commercially-available devices (*i.e.*, those actually on the market and available for delivery) and to a few other pertinent topics.

The prevailing overall impression is one of substantial advances in the state-of-the-art of breath-alcohol analysis during the past five years, with major emphasis on instrumentation utilizing physical, physical-chemical, and other than 'wet-chemistry' principles and approaches. The resulting apparatus instruments and devices have achieved substantial sophistication, especially with respect to alcohol detection and quantitation (now often referred to as 'sensing'), and a considerably lesser degree of adequacy and sophistication in regard to breath sampling and other biological aspects. While considerable attention has recently been focused on several formerly quiescent factors in breath-alcohol analysis, such as the issue of specificity of the analyses of ethanol, few if any meaningful advances have addressed these issues during the interval covered.

The past several years have seen the entry of large industrial organizations into what was originally a cottage industry, and both the nature and rate of technological developments and manufacturing practices respecting breath-alcohol instrumentation is consequently undergoing profound changes. In substantial measure, these changes and the entry of large corporations into the field have been the result of the increasing federal presence (in the United States) in traffic safety matters in general and in the problems of alcohol, other drugs and traffic in particular (20, 16). Federal involvement has taken the form of substantial funding, and the concomitant development of equipment and performance specifications, standards, legal requirements, and evaluations in various aspects of the field, including that of breath-alcohol instrumentation and methodology in particular.

In December 1973, Dr. H. A. Laitinen (the Editor of *Analytical Chemistry*) described a "common set of seven phases through which an analytical method passes" (13):

---

[1] Departments of Medicine, Biochemistry, and Pathology, and Toxicology Laboratories, University of Oklahoma College of Medicine, Oklahoma City, Oklahoma 73190.

1) Initiation or conception phase
2) Experimental measurements to establish the validity of the principle as the basis for useful measurements
3) Developments in instrumentation to bring the method from a laboratory curiosity into the hands of the nonspecialist
4) Pursuit of detailed studies of principle and mechanisms, with the aid of improved instrumentation
5) Enlargement of applications to an ever-widening scope of areas with appropriate modifications in procedures
6) Applications of well-established procedures to new as well as old problems, with high standardization of certain procedures
7) A period of senescence, as other methods of greater speed, economy, convenience, sensitivity, selectivity, etc., surpass earlier methods.

It is interesting to note that each of these phases can be identified in the historical development of breath-alcohol analysis as a broad technological area and in the time-course of representative individual methods for alcohol analysis in breath. For several principles of alcohol analysis, steps 4, 5 or 6 (and for a few, step 7) have now arrived in full. The progressive development and maturation of breath-alcohol analysis as a discrete technological area is reflected in Table I as a breath-alcohol apparatus classification scheme which demonstrates that the fourth generation of such devices has now been reached. In terms of leading analytical principles for breath-alcohol analysis, a comparison between the situations in 1969 and 1974 is given in Table II. The strong trend toward physical-chemical principles of analysis is clearly evident.

TABLE I *Commercial Breath-Alcohol Instrumentation (U.S.A.)*

FIRST GENERATION	
	Drunkometer (1938)
	Alcometer (1941)
	Portable Intoximeter (1941)
SECOND GENERATION	
	Breathalyzer (1954)
	Photo-Electric Intoximeter (1958)
	Alco-Textor (1965)
THIRD GENERATION	
	Alco-Analyzer (1968)
	GC-Intoximeter Mark II (1968)
	Alcometer Model D-L (1968)
	Automatic Breathalyzer (1971)
	Intoxilyzer (1971)
FOURTH GENERATION	
	Alco-Limiter (1972)
	A.L.E.R.T. (1972)
	Alco-Sensor (1973)

TABLE II *Leading Technologies in Breath-Alcohol Analysis*

1969
Chemical Oxidation & Photometry
Gas Chromatography
1974
Chemical Oxidation & Photometry
Electrochemical Oxidation
Fuel Cell Catalysis
Gas Chromatography
Infrared Photometry
MOS Gas-Sensing

BREATH-ALCOHOL INSTRUMENTATION

Overview

Broad trends, as well as specific developments with respect to individual breath-alcohol analysis instruments are reflected in Tables III and IV. Between 1969 and 1974, the number of quantitative evidential devices on the market increased, the number of screening test devices decreased, and both accessories for breath-alcohol analysis devices and devices for breath collection for subsequent remote analysis increased substantially in number. The trend in newly developed devices was markedly toward self-contained electrically-powered instruments utilizing physical-chemical principles, such as semiconductor alcohol-sensing and fuel-cell electro-chemical oxidation. For the first time in about 30 years, several automated instruments appeared, in which various sequential operational steps (e.g., purging, sampling, analysis, result display) are interlocked and carried out without analyst intervention or control.

TABLE III *Commercial Breath-Alcohol Devices: 1969*

QUANTITATIVE EVIDENTIAL DEVICES	SCREENING TEST DEVICES
Alco-Analyzer	Alcolor Breathmeter
Alcolinger Automatic	Alcolyser
Alcometer, Model DE	Alcotest
Alco-Tector	Drunk-O-Tester
Breathalyzer	Pluracol-Sonde
Drunkometer	Sober-Meter
Ethanographe	
GC Intoximeter, Mark II	
Photo-Electric Intoximeter	
ACCESSORIES	**COLLECTION DEVICES**
Equilibrator	Accutube
Simulator	Alcolyser ASC
	DPC Intoximeter
	Intoximeter Field Crimper
	Portable Intoximeter

Result displays in newly developed instruments are generally by means of digital devices, or indicator lamps, and analog result presentations are being phased out. To increase the probative value of the analyses, simultaneous multi-copy result printouts are available as options; and in several instruments interlocks prevent completion of the full test sequence (with indication of the aborted test) if tampering occurs or intervention is attempted (e.g., by alteration of zero controls or opening of instrument covers).

With increasing sophistication and optional convenience and probative-value features, apparatus costs have increased sharply. Maintenance and repair have likewise become much more complex, and have, in general, become factory rather than field operations. Modular components, including printed circuit boards and other state-of-the-art electronic components for power, control, and display functions are widely employed in the newer devices.

TABLE IV *Commercial Breath-Alcohol Devices: 1974*

QUANTITATIVE EVIDENTIAL DEVICES
Alco-Analyzer
[a]Alcoholic Detector
[a]Alco-Limiter
Alcolinger Automatic
Alco-Tector
Breathalyzer, Model 900A
[a]Breathalyzer, Model 1000
Ethanographe
GC Intoximeter, Mark II
[a]Intoxilyzer
Photo-Electric Intoximeter

ACCESSORIES
[a]Alco-Analyzer Digital Readout
[a]Breathalyzer Transfer Unit
[a]GC Intoximeter Digital Readout
[a]Nalco Alcohol Standard Simulator
[a]Standard Alcohol Sample

SCREENING TEST DEVICES
Alcolyser
[a]Alco-Sensor
Alcotest
[a]A.L.E.R.T.
[a]Alveolar Air Breath-Alcohol System

COLLECTION DEVICES
Accutube
Alcolyser ASC
[a]Breathalyzer Collection Unit
DPC Intoximeter
Intoximeter Field Crimper
Portable Intoximeter
[a]Sober-Meter SM-7
[a]Vacu-Sampler

[a] Developed Since 1969

Finally, there has been a significant increase in the number and variety of prototype devices and instruments for breath-alcohol analysis which have been developed to the pre-production stage, but have not been produced or marketed. There is much evidence of the attempted penetration of this specialty market by a significant number of new entrepeneurs, planning technology-transfers from aerospace, electronics, and other high-technology fields.

Significant breath characteristics (e.g., temperature, volume, and pressure) needed for improved breath-alcohol device design were studied by Dubowski (7).

Quantitative Evidential Devices

Newly introduced quantitative evidential breath-alcohol devices are shown in Table IV. Each of these four instruments utilizes a different analytical principle:

Alcoholic Detector (Toshiba). Ethanol conversion to hydrogen by catalytic reduction and H_2 detection by an ionization vacuum tube.

Alco-Limiter (E.S.I.). Chemoelectric oxidation, at a potential-controlled electrode, monitored by current flow.

Automatic Breathalyzer (Smith & Wesson). Acid-dichromate oxidation and Bunsen-principle photometry.

Intoxilyzer (Omicron). Absorbance of infrared light, feedback control-loop stabilized, at a fixed wavelength, and A-D conversion of the sample-blank absorbance difference.

Interestingly, while each of these alcohol quantitation methods has some selectivity for ethanol, none is characterized by ethanol specificity. The last three devices present results as corresponding blood-alcohol concentrations and are calibrated on the basis of a blood/breath alcohol ratio of 2100:1; the Alcoholic Detector presents breath-alcohol concentration results over the range of 0.1 to 1.0 mg/liter.

Breath-sampling arrangements also differ in each instrument (in the same sequence): 1) mixed expired breath collected in a fixed-volume balloon, 2) fixed time period sampling with initial breath discard monitored by flow-sensor and subsequent trapping of analyzed sample, 3) initial breath discard by means of an overflow piston-cylinder chamber, and trapping of the analyzed sample in another piston-cylinder chamber, 4) flow-through sampling, monitored by pressure sensor, for a fixed time period and analysis of the retained sample.

Presentation of results is also accomplished by four different means: 1) recording on an integral miniature stripchart recorder, 2) analog-meter indication, with optional 2-digit card-printer, 3) 2-digit result display and integral 2-digit card-printer, 4) optional 2 or 3-digit result display and integral 2-digit card-printer.

Little information is so far available on the performance of these new devices, especially in human subject tests, and detailed evaluations have not been published for any of them. Tables V and VI contain *in-vitro* precision and accuracy and *in-vivo* accuracy data for the Model 1000 Automatic Breathalyzer (1). Preliminary data on performance of the Intoxilyzer were given by Harte (11).

TABLE V *In-Vitro Precision and Accuracy of the Model 1000 Breathalyzer*[a] *(1)*

	Nominal Blood Alcohol Concentration		
Test	0.050%	0.100%	0.150%
1	0.051	0.107	0.151
2	0.048	0.100	0.149
3	0.047	0.101	0.149
4	0.048	0.099	0.143
5	0.051	0.104	0.144
6	0.047	0.098	0.146
7	0.044	0.095	0.144
8	0.048	0.097	0.144
9	0.049	0.102	0.151
10	0.050	0.098	0.144
Average ($\bar{X}$)	0.0483	0.1001	0.1465
Systematic error:	-3.4%	+0.1%	-2.3%
Standard deviation:	0.0021%	0.0036%	0.0032%

[a] Test results of ten sample measurements made on each of three known alcohol vapor concentrations–summary.

TABLE VI *In-Vivo Accuracy of the Model 1000 Breathalyzer (1)*

Subject	Blood-Alcohol Concentration, %w/v, Obtained by Analysis of Blood	Breath
1	.052	.050
	.054	.046
2	.068	.061
	.065	.061
3	.069	.064
	.069	.061
4	.093	.094
	.093	.088
5	.101	.090
	.111	.089
6	.105	.113
	.100	.105
7	.113	.115
	.117	.117
8	.120	.121
	.120	.106
9	.043	.037
	.047	.038
10	.061	.063
	.063	.059

Preliminary results of so-called "qualification tests" for nine quantitative evidential breath-alcohol analysis devices were disclosed by the Transportation Systems Center in June 1974 (21) without identification of the specific instruments tested. Results of the *in-vitro* precision and accuracy tests and of the human subject test correlations in this series are shown in Tables VII and VIII.

Screening-Test Devices

Most of the recent activity in breath-alcohol instrumentation development has been concentrated on screening test devices. Several of the recent quantitative evidential units are, in fact, upgraded instruments originally intended as screening test devices. Much of the commercial incentive for development of screening test devices arose from the interest of the U.S. Department of Transportation (DOT) in an instrument which would meet certain preliminary conceptual and design specifications (17) and from the subsequent DOT industry-wide solicitation of bids for production of 1000 screening test units (14, 25).

The newly-developed screening test devices are listed in Table IV. It will be noted that despite vast publicity and pre-production activities on the part of several major manufacturers, only three new devices actually reached and remained on the market between 1969 and 1974. Two are self-contained instruments, and one (the Alveolar Air Breath-Alcohol System), is a single use length-of-stain oxidimetric screening device.

TABLE VII *DOT/TSC Qualification Test Series #1 for Quantitative Evidential Breath-Alcohol Devices: In-Vitro Accuracy and Precision Tests (21)*

Breath-Alcohol Device	Mean Device Result[a] ± S.D.[a] at 50 mg/dl	100 mg/dl	150mg/dl
Standard	45-55	95-105	142.5-147.5
1	50 ± 0.7	102 ± 1.7	150 ± 2.2
2	52 ± 4	97 ± 2.7	144 ± 3.0
3	49 ± 1.8	96 ± 2.5	145 ± 2.3
4	51 ± 2.5	104 ± 2.8	152 ± 3.1
5	51 ± 2.3	102 ± 2.4	149 ± 4.9
6	50 ± 1.9	98 ± 2.4	146 ± 2.2
7	51 ± 2.5	100 ± 3.3	154 ± 2.5
8	51 ± 2	97 ± 2	144 ± 1.5
9	52 ± 1.0	98 ± 2.5	153 ± 1.5

[a] Expressed as Corresponding BAC in mg/dl

TABLE VIII *DOT/TSC Qualification Test Series #1 for Quantitative Evidential Breath-Alcohol Devices: Human Subject Tests (21)*

Breath-Alcohol Device	Breath-Derived Result[a] at 100 mg/dl BAC	No. of Subjects Within ± 20 mg/dl of Correlation Line
Standard	80-100	7
1	80	8
2	77	8
3	83	8
4	84	8
5	82	8
6	70	8
7	77	8
8	86	8
9	80	8

[a] Expressed as Corresponding BAC in mg/dl

Alcohol analysis is by three different principles:

Alco-Sensor (Intoximeters). Chemoelectric (fuel-cell) oxidation

A.L.E.R.T. (Borg-Warner). N-type semiconductor alcohol-sensing

Alveolar Air Breath-Alcohol System (Becton-Dickinson). Acid-dichromate oxidation monitored by color change (length-of-stain).

The breath-sampling arrangements differ in all three instruments: 1) operator-controlled sampling period, with retention of last-delivered specimen portion, 2) initial breath discard for a fixed time period through by-pass and flow-through monitored by pressure sensing, and trapping of the last-delivered specimen portion, 3) initial breath discard into a fixed-volume container, and delivery of next-delivered specimen into a coupled fixed-volume plastic container.

Result presentations vary considerably: 1) analog ammeter indication with a single calibration mark, 2) 3-light (Pass, Warn, Fail) indications at field-calibrated breath-alcohol concentrations, and 3) length-of-stain indication, compared with a printed scale.

The alcohol detection principle which has received the most attention for screening test applications is N-type semiconductor sensing by means of the Taguchi gas-sensing semiconductor device (26). This system employs a detector based on a porous metal oxide semiconductor element, which manifests reproducible changes in electrical conductivity when in contact with certain combustible or reducing gases or vapors. Integral electrodes and heating elements are contained in the MOS sensor, and a variety of electronic circuits are utilized to condition the detector and to relate the electrical conductivity changes to digital breath-alcohol concentration values or lamp signals. The Taguchi sensor is currently the most commonly employed alcohol transducer, although most of the various devices based on its use are still in the prototype or earlier stages. Recent development efforts have centered on attainment of linear response over the breath-alcohol concentration range of interest and on attempts to increase the selectivity of the detector response to ethanol, *i.e.*, to limit its response to other actual or potential breath components.

Considerable work has also been carried out with fuel-cell detectors for breath-alcohol screening devices. Electrochemical oxidation is accomplished at surfaces catalyzed with precious metals in potential-controlled electrodes. Alcohol is oxidized to acetic acid and the resultant current flow is measured with analog meters or used to trigger indicating lamps.

Several of the newer screening test devices have been evaluated in laboratory studies of either the actual commercial products or the alcohol-sensing components. Performance of the B-D Alveolar Air Breath-Alcohol System has been reported by Prouty and O'Neill (19). Field comparisons of the Alco-Sensor and A.L.E.R.T. units with Model 900A Breathalyzer results were reported by Blount (3, 4). A comprehensive laboratory evaluation of the Alco-Sensor has been reported by Jacobs and Goodson (12).

Several length-of-stain screening test devices have been studied in comprehensive *in-vitro* tests by Dubowski (9) and the precision of several such devices in the measurement of simulator-produced air-alcohol concentrations is summarized in Table IX, which illustrates a better potential for alcohol quantitation than the comparison studies of Prouty and O'Neill (19) and others have demonstrated. One conclusion is is that substantially better breath-sampling systems are required, which is in accordance with the experimental findings of Dubowski (7).

TABLE IX *Precision of Alcohol Quantitation with Several Breath-Alcohol Screening Devices: Length-of-Stain Measurements (9)*

Device	Nominal BrAC	N	Stain Length, mm. Mean	S.D.	C.V.
Alcolyser	100 mg/210 L.	57	4.70	± 0.275	5.8%
Alcotest	80 mg/210 L.	50	5.45	± 0.225	4.1%
Alveolar Air Breath-alcohol System	100 mg/210 L.	59	10.94	± 0.617	5.6%
Sober-Meter	100 mg/210 L.	50	4.06	± 0.336	8.3%

Based on experience with length-of-stain devices and earliest prototypes of screening test instruments, the original U.S. Department of Transportation specifications anticipated a requirement that 95% of breath-alcohol screening test results should fall within ± 20% of the true value (10). More recent experience with prototype and early production devices for breath-alcohol screening has indicated substantially better routine performance capabilities, and it now seems probable that the typical production breath-alcohol screening instrument will be able to achieve results within ± 10% of the true breath-alcohol value consistently.

Accessories and Collection Devices

Tables III and IV reflect changes in the availability of accessories for breath-alcohol analysis instruments and of devices for field collection of breath specimens for subsequent analysis in another location. Partly through legislative enactment and partly through popular demand, direct digital readout accessories which display the results to two decimals (as the corresponding blood-alcohol concentration in percentage weight by volume) have become available for several earlier instruments which originally had only stripchart result displays.

In addition to breath-alcohol simulators (*i.e.*, temperature-controlled equilibrators for producing known concentrations of alcohol in air), several types of alcohol-in-gas reference samples are now available in small pressurized cylinders or aerosol containers. Since these gas mixtures must be devoid of water vapor for stability under pressure, they cannot be used for calibration or verification analyses with certain breath-alcohol instruments sensitive to water vapor.

Several new devices for field collection of breath specimens have appeared recently. The Breathalyzer Collection Unit (8) consists basically of the breath sampling cylinder and valve of the standard Breathalyzer, arranged to deliver a fixed volume of end-expiratory breath through a calcium chloride column which absorbs and retains any alcohol present. The Breathalyzer Transfer Unit can be employed later to pass a heated air stream through the $CACl_2$ column, eluting the alcohol and delivering it directly into the reagent ampoule of a Breathalyzer, the calibration of which is directly applicable to these remotely collected specimens. The SM-7 device is a field collection unit composed of a fixed-volume bag for initial breath discard and a silica-gel column connected to another fixed volume bag for measurement of the breath sample from which the alcohol has been absorbed, for subsequent elution and laboratory analysis by gas chromatography or other convenient means. The Vacu-Sampler (18) is a device for field collection of unaltered breath specimens after initial operator-controlled breath discard. It accepts a breath volume controlled by the initial fixed vacuum of the canister and the ambient atmospheric pressure, and allows for addition of an internal standard for subsequent gas chromatographic analysis of the breath-alcohol content of the sample.

Prototype Devices and new Procedures

Both the government and industry have developed a number of breath-alcohol analysis devices to the prototype stage during the past several years. Table X lists those screening test devices which have been publicly announced. In most instances, no further details are currently available publicly, but at least three of these devices (Alcohalt, A.L.E.R.T. J-3, and B.A.T.), or redesigned versions thereof, will be produced in limited numbers under recently awarded DOT contracts.

TABLE X *Breath-Alcohol Analysis 1974: Announced Prototype Devices and new Procedures*

DEVICES

NAME	MANUFACTURER	ALCOHOL SENSOR
Alcohalt	Mine Safety Appliances Co.	Catalytic Burner
Alcotron II	Reaction Instruments, Inc.	Taguchi MOS
A.L.E.R.T. (J-3)	Borg-Warner Corp.	Taguchi MOS
A.S.D.	TSC, US Dept. of Transportation	Fuel Cell
Breathometer	Smith & Wesson Electronics Co.	Fuel Cell
CGS-4	Environmental Metrology Corp.	Taguchi MOS
H.A.L.T.	Borg-Warner Corp.	Catalytic Burner
Breath Analyzer (BAL-1)	General Electric Co.	Infrared Photometer
B.A.T.	Century Systems Corp.	Catalytic Burner

PROCEDURES

Automated Gas Chromatographic Breath-Alcohol Analysis (Dubowski, 1974)

Once again, it is interesting that all of these prototype devices utilize physical-chemical or 'solid state' alcohol sensing, rather than standard chemical methods. Certain other candidate analytical principles (e.g., gas chromatography) are effectively eliminated by the requirements for portability, self-contained power supplies, internal calibration, etc. which will characterize the next generation of screening test devices. Since these devices are intended only for screening tests, specificity or high selectivity for ethanol is not an invariant requirement, leading to such analytical approaches as use of non-dispersive infrared absorption in the Breath Analyzer, and use of catalytic burners in several other units.

An automated method for breath-alcohol analysis has been reported by Dubowski (6). Whole breath specimens are collected in 24 ml. glass vials and are subsequently analyzed by automated gas chromatographic analysis using the Perkin-Elmer Multifract F-40 instrument developed originally by Machata for automated gas chromatographic headspace analysis of blood specimens.

OTHER RELATED DEVELOPMENTS

The National Safety Council's Committee on Alcohol and Drugs made a series of policy recommendations in recent years which have provided guidance to the public and private sectors concerning criteria of acceptability for alcohol analysis methods and devices, and related matters. The "Recommendations of the Ad Hoc Committee in Testing and Training" (24) in 1968 proposed, inter alia, that only breath specimens be analyzed in which the ethanol was substantially in equilibrium with the alcohol of the pulmonary blood circulation, and further recommended that quantitation of breath specimens be accomplished only by direct volumetric measurement or by collection and analysis of a fixed/breath volume. This effectively eliminated use of the alcohol/carbon dioxide ratio and of mixed expired breath in breath-alcohol analysis.

The "Recommendations of the Ad Hoc Committee on Quantitative Breath Alcohol Instrumentation" (23) in 1971 next proposed certain standards for quantitative evidential breath-alcohol instruments and recommended stipulated performance requirements, as well as a monitoring and approval system for breath-alcohol instruments to be used in traffic law enforcement. The present quantitative instrument standards developed by the U.S. National Bureau of Standards in collaboration with other concerned groups, and the apparatus evaluation activity of the DOT Transportation Systems Center are direct outgrowths of those recommendations.

In 1972, the "Recommendation of the Ad Hoc Committee on Breath Alcohol Tests" (22) followed and provided guidelines for selection, evaluation, and approval of screening devices which have formed the basis for proposed DOT standards for screening devices presently in final stages of consideration.

Three other source documents are of pertinence and significance in connection with the continuing attempts to upgrade breath-alcohol analysis in all aspects: 1. "Concepts and Standards of Practice in the Analysis of Alcohol in Physiological Specimens as Promulgated by the California Association of Criminalists" (5) 2. "Recommendations of the Canadian Society of Forensic Science on Breath Testing Standards & Procedures" (2) 3. "Standard for Devices to Measure Breath Alcohol" (15). The last, dealing with instruments for quantitative evidential breath-alcohol analysis, is the first of a series of U.S. federal government standards which has already made a substantial impact on the entire field. Subsequent standards will deal with devices for breath-alcohol screening tests and calibrating devices and procedures.

These several sets of proposals, recommendations, and standards will undoubtedly continue to influence the field of breath-alcohol instrumentation for many years.

REFERENCES

1. Altshull, S., *A Process Capability Study of the Model 1000 Breathalyzer.* Indiana University, Bloomington, Indiana, July 1973.
2. Bergh, A. K., et al., Recommendations of the Canadian Society of Forensic Science on Breath Testing Standards & Procedures, *Canadian Society of Forensic Science Journal 2,* 88-93 (1969).
3. Blount, W. R., *Alco-Limiter and A.L.E.R.T. Portable Units in a Field Setting Using the Steven's 900A as Criterion.* Greater Tampa Alcohol Safety Action Project, Tampa, Florida, Nov. 1973.
4. Blount, W. R. *Alco-Sensor and A.L.E.R.T. Portable Units in a Field Setting Using the Steven's 900A as Criterion.* Greater Tampa Alcohol Safety Action Project, Tampa, Florida, March 1974.
5. Brackett, J. W., et al., Report of the Alcohol Analysis Committee of the California Association of Criminalists, *Journal of the Forensic Science Society* 9, 54-57 (1969).
6. Dubowski, K. M., An Automated Gas Chromatographic Method for Analysis of Ethanol in Breath, *Clinical Chemistry* 20, 861 (1974).
7. Dubowski, K. M., Biological Aspects of Breath-Alcohol Analysis, *Clinical Chemistry* 20, 294-299 (1974).
8. Dubowski, K. M., Measurement of Ethyl Alcohol in Breath. In *Laboratory Diagnosis of Diseases Caused by Toxic Agents,* F. W. Sunderman and F. W. Sunderman, Jr., (Eds). Warren H. Green, Inc., St. Louis, Missouri, 1970, pp. 316-342.
9. Dubowski, K. M., Unpublished observations, April 1974.
10. Harriott, W. F., *Status Report on Alcohol Screening Device Development in the United States.* U.S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts, June 1972.
11. Harte, R. A., An Instrument for the Determination of Ethanol in Breath in Law Enforcement Practice, *Journal Forensic Sciences* 16, 167-184 (1971).

12. Jacobs, W. B., and Goodson, L. H., *Evaluation of the Intoximeter Fuel Cells for Breath Alcohol Testing. Part II – The Alco-Sensor.* Midwest Research Institute, Kansas City, Missouri, Jan. 1973.
13. Laitinen, H. A., The Seven Ages of an Analytical Method, *Analytical Chemistry* 45, 2305 (1973).
14. *LRTP NHTSA-4-A001, Request for Technical Proposal (Breath Screening Tester).* U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, D.C., Aug. 30, 1973.
15. National Highway Traffic Safety Administration, U.S. Department of Transportation, Standard for Devices to Measure Breath Alcohol, *Federal Register* 38, 30459-30463 (Nov. 5, 1973).
16. *1968 Alcohol and Highway Safety Report.* U.S. Government Printing Office, Washington, D.C. 1968.
17. Oates, J. F., and Jacobs, H. H., *Preliminary Operational Requirements and Acceptability Criteria for the Cooperative Breath Analyzer.* Dunlap and Associates, Inc., Darien, Connecticut, Sept. 1971.
18. Principe, A. H., et al., Gas Sampling Apparatus and Method, U.S. Patent 3,618,393 (Nov. 9, 1971).
19. Prouty, R. W., and O'Neill, B., *An Evaluation of Some Qualitative Breath-Alcohol Screening Tests for Alcohol.* Insurance Institute for Highway Safety, Washington, D.C., May 1971, pp. 32-36.
20. *Public Law 89-564, The Highway Safety Act of 1966.*
21. *Qualification Testing of Evidential Breath Testers – Preliminary Report: Qualification Test Series #1.* U.S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts, June 1974.
22. *Recommendations of the Ad Hoc Committee on Breath Alcohol Screening Tests, National Safety Council Committee on Alcohol and Drugs.* Warrensburg, Missouri, Jan. 11-13, 1972.
23. *Recommendations of the Ad Hoc Committee on Quantitative Breath-Alcohol Instrumentation of the Committee on Alcohol and Drugs of the National Safety Council.* Florissant, Colorado, April 21-23, 1971.
24. *Recommendations of the Ad Hoc Committee on Testing and Training of the Committee on Alcohol and Drugs, National Safety Council.* Florissant, Colorado, April 29-30, 1968.
25. *Request for Proposal No. TSC/R & D TI-0007: Development of Instrumentation for the Roadside Measurement of Blood Alcohol Level (BAL).* U.S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts, Oct. 30, 1970.
26. Taguchi, N., Semiconductor Gas Detecting Device, U.S. Patent 3,732,519 (May 8, 1973).

Aspects of Drug Analyses in Relation to Road Traffic Legislation and Supervision

Roger Bonnichsen[1]

Each country has its own structure and traditions which help formulate the methods used to deal with alcohol and drugs in relation to traffic safety. The legislation, the Court's interpretation of the law, the influence of temperance movements, the public attitude towards drinking and driving, the number of cars driven, the number of people killed and injured on the roads, the accessibility of alcohol and drugs, the resources available to the police to control the traffic, and the organization of forensic sciences are some of the factors that vary from country to country. Therefore, instead of attempting to deal with the problem in general, this paper will describe the situation in Sweden alone.

Since the analytical technique of the analytical laboratory must be in accordance with the law I will give a short historical survey of the development of legislation concerning alcohol, drugs and driving. Because most cases of drug misuse which come to our attention are intimately connected with a high alcohol consumption, it is not possible to separate the question of drugs in relation to traffic from that of alcohol: they belong together and must consequently be discussed together.

FACTORS CONCERNING ALCOHOL AND DRUG USE IN SWEDEN

Background to the Present Legislation

Since 1923 (1920) Sweden has had legislation concerning drinking-driving. Charges could be laid when it could be "assumed the operator was intoxicated by alcohol". In 1941, after the Widmark micromethod for determination of alcohol in blood had been thoroughly tested, new legislation concerning two blood alcohol concentrations (BACs) were passed; one at 0.15% and another at 0.08%. Above 0.15% the driver was assumed unfit to drive and the penalty was one to two months in jail. For a BAC between 0.08% and 0.15% he was usually fined, but in both cases the driving license was withdrawn for a period of two years, and in the case of an accident the insurance was deemed invalid.

In 1957 the lower legal level was reduced to 0.05%, which is the lowest possible usable level because in many small or fat persons the BAC may decrease at a rate of

---

[1] National Institute for Forensic Chemistry, 104 01 Stockholm 60, Sweden.

0.03% to 0.04% per hour. It can be mentioned in passing that at a BAC of 0.05% the alcohol-dehydrogenase is just saturated with substrate. It is important to keep in mind that the law refers to the time when actual driving takes place and not to the moment when the blood sample happens to be taken. Consequently the BAC will almost always be either higher or lower during the driving; the same is true for the intoxication.

In 1966 a new committee was appointed to revise the Act. The committee's main suggestion, made in 1970, was to lay charges on the basis of the alcohol level found at the time the sample was taken. A further suggestion was that the upper limit should be lowered to 0.12%. As most drunken drivers are alcoholics or misusers of alcohol, the committee recommended that, instead of a jail sentence, some sort of probation combined with a fine and medical treatment for alcohol or drug problems should be instituted. So far, no change has been made in the law. However, over the last two years several hundred people have been fined and placed on probation provided that they submit themselves regularly to medical treatment. We do not know if this system is working as there has been no follow-up as yet.

It was not until 1951 that a new section was added to the Act which also made it a criminal liability to drive under the influence of intoxicants other than alcohol. It is of great importance that the wording is the same as in the Act concerning alcohol: "If it can be assumed that the operator is incapable of safe driving". The only possible penalty for this offence is a jail sentence, which explains the rigorous proof the court demands.

The history of the quantitative determination of drugs in blood and urine is a very short one and in 1951 it was almost impossible to determine drugs other than barbiturates accurately. It was the epidemic use of substances stimulating the central nervous system (CNS) which reached Sweden in the early sixties that really started the demand for the determination of presence and quantity of narcotics and other drugs in the blood and urine of intoxicated drivers. Further, it should be mentioned that even the history of psychopharmacology is a short one and it took some time before the danger of these drugs to highway safety was noticed. Thus it seems that the last 25 years have seen the development of many psychopharmacological determinations of drugs, and in the same period, a tremendous increase in both the number of cars and of traffic victims. Tables I, II and III show the development.

TABLE I *Number of Motor Vehicles in Sweden*

Year	Cars	Motorcycles	Mopeds
1951	410,362	258,451	
1956	855,148	266,786	Numbers not known, probably several hundred thousand
1969	2,349,815	42,948	
1972	2,617,973	37,198	
1973	2,666,784	–	

Amount of Alcohol and Drugs Consumed

In 1973 Sweden spent 6,160 million kronor on alcohol and, on average, each person over 15 years old consumed 5.8 liters of 100% alcohol. Compared to other countries this is not a large quantity. To the above figures should be added the illicitly distilled liquor, the home-made wines and the liquors imported by travellers. As in all other countries most of the alcohol is consumed by only a small segment of the population.

In 1972 Sweden spent about 1,600 million kronor on drugs of all kinds and about 800 million pills were sold, including sleeping tablets, sedatives or ataractics. This number of tablets does not include the drugs that can be bought at the drug store without a prescription. (Of course, a great deal of this medication is not consumed.) The medical use of drugs is probably more evenly distributed amongst the population than is the use of alcohol, but the three types mentioned above will, as a rule, only be misused by a smaller fraction of the population. They are used to a large extent by alcoholics and by persons suffering from psychic or nervous diseases. Table IV shows the number of tablets of the various types of drugs sold.

TABLE II *Number of People Killed and Injured in Traffic*

	Drivers			Total number[a]		
Year	Killed	Severely injured	Slightly injured	Killed	Severely injured	Slightly injured
1956	116	434	3,063	889	3,275	15,945
1969	376	2,033	5,937	1,275	6,529	16,670
1972	385	2,180	8,190	1,194	6,657	22,450
1973	385	2,418	8,770	1,174	7,264	23,728

[a] Comprising motorcycles, mopeds, bikes, pedestrians and passengers.

TABLE III *Total Number of Samples 1972-1974 for Alcohol and Drug Determination*

Year	Number of blood samples	Number of venous blood samples	Number of blood samples without alcohol
1972	20,956	884 (3000)[a]	292 (218)[b]
1973	21,711	812 (3000)	211 (156)
1974[c]	10,185	427 (1500)	84 (55)

Note: The laboratory usually gets the blood for alcohol determination in Widmark capillaries along with a sample of uring. For drug analyses we get 10 ml of blood.

[a] Number of persons who admit having taken drugs, but no sample for drug analysis was taken.

[b] The number of samples analysed.

[c] 6 month period.

TABLE IV *Number of Tablets Containing Sedatives and Psychopharmacological drugs sold in Sweden (in millions)*

Drug	1971	1972
Barbiturates	52.5	45.7
Benzodiazepins and pharmacologically related drugs	371.5	336.6
Antipsychotic drugs	178.0	185.9
Tricyclic amines	95.4	93.4
Combination of analgetica and sedatives	144.0	137.4
TOTAL	841.4	799.0

Detection of Operators Under the Influence of Alcohol or Drugs while Driving

Alcohol, unlike other drugs, can be smelled and the "alcotest" is a rapid way of detecting it. However, some studies initiated by the committee mentioned above revealed that the police in a simulated road block missed the smell of alcohol and other signs of intoxication when a BAC was below 0.15%. No experiments have been performed to see what chance the policeman has of detecting other drugs causing impairment, but it is probable that a person must be greatly affected by the drug before suspicion is aroused. Thus, when drugs are used in therapeutic amounts, or in amounts below the tolerance level of the person taking them, they are likely to go undetected. Because of the difficulty in detecting these drugs the main cause of capture of drivers using them is a report to the police officer that a car is a danger to the traffic or is involved in an accident whereupon the operator is found by the police to be intoxicated. Thus all the drivers from whom we get blood for drug (other than alcohol) analysis are visibly impaired and have therefore more than the medically prescribed dose of one of several drugs.

Many drugs are of course used in therapeutic amounts and are therefore undetectable. After all, we prescribe a drug for the effect it will have; for example, as a muscle relaxant, a sedative, an antihistamine or as an antidepressant. However, in so doing we somehow depress or simultaneously affect other sense organs that may be important for safe driving. Thus the problem of the part played by therapeutic amounts of drugs in traffic accidents and the general prescription of drugs to drivers is a matter that should be dealt with by the medical profession. In Sweden doctors are obliged to inform patients about possible traffic risks, resulting from the medications they prescribe.

If a person is injured and brought to hospital the police can ask for a blood sample only if they suspect that the driver is drunk or intoxicated by drugs. Liquor found in the car or the smell of alcohol on the breath gives enough justification to the police to measure a BAC. However, they have great difficulty in justifying analysis for other drugs. We therefore know little about alcohol combined with other drug consumption in regard to injured drivers. A few investigations made by the staff of some of the hospitals show that many of the injured had been drinking. The difficulty in obtaining data is that the patient must give permission before a sample can be taken. Many refuse and a sample from an unconscious patient is, *ipso facto*, out of the question.

Table V shows the frequency with which different drugs were found in some selected years. Tables VI and VII show why drugs were taken and which drugs were mixed with alcohol.

TABLE V *The Frequency of Various Drugs found in Blood or Urine (no alcohol present)*

Substance	Years 1964	1969	1972	1973	1974[a]
Stimulating CNS	1	38	109	52	20
Barbiturates	10	31	11	16	4
Aromatic hydrocarbons	0	38	10	14	6
Benzodiazepins	2	54	29	20	9
Meprobamate	4	6[b]	6	1	2
Methaqualone	0	15	15	5	1
Tricyclic amines	0	1	4	2	0
Various[c]	3	38	26	21	7
Several drugs found[d]	0	0	18	25	6
TOTAL	20	211	228	156	55

[a] 6 month period

[b] In 1967, 35 cases

[c] For example, salixylic acid, chlormethiazole, dextropropoxyphene, fenazone, glutethimide, chloral hydrate.

[d] For example, acetylsalicylic acid plus benzodiazepines plus barbiturates.

TABLE VI *Some Cases in which only Widmark Capillaries for Alcohol Determination were taken, April and May 1974*

Reason for Medication	Reason for police Intervention	Drug	BAC %	Age
Anxiety	Forgot his lights	Propranolol	0.14	42
Epilepsy	Accident	Diphenylhydantoin	0.17	27
Ischias	Reported by other drivers	Phenprobamate Acetylsalicylic acid Dextropropoxyphene	0.26	38
Nervous disease	Accident	Valium Methaqualone	0.21	26
Stomach trouble	Control	Valium Dextropropoxyphene Phenazone Acetylsalicylic acid	0.23	51
Toothache	Unsteady driving	Acetylsalicylic acid	0.29	64
Nervous disease	Unsteady driving	Meprobamate	0.14	41
Allergy	Accident	Antihistamines	0.08	28

TABLE VII *Some Examples of Cases in which a Blood Sample was taken for Drug Analysis, but no Analysis was made, April - May 1974*

Reason for Medication	Reason for Police Intervention	Drug	BAC %	Age
Anxiety	Accident	Phenothiazine Valium	0.13	24
Inhalation	Accident	Organic solution	0.11	16
Pain in the back	Accident	Dextropropoxyphene Acet. salic. acid Phenazone	0.23	44
Nervous disease	Accident	Valium	0.18	43
Ulcer and nervous disease	Unsteady driving	Librium plus other things	0.14	39
Alcoholic	Accident	Anticonvulsive Valium Barbiturates	0.14	31
Epilepsy and lung inflammation	Control	Anticonvulsive Penicillin Cough mixture	0.12	–

Proof Needed for Conviction for Impairment by Drugs Other than Alcohol

Before a prosecutor can obtain a conviction it must be proved that the driving concerned was somehow a hazard to traffic. Although the observations by the police or passers-by are accepted as proof, the fact that an accident has occurred is seldom taken to prove that the driver must have been a danger.

It must also be proved that the operator took some substance that makes him unfit for driving. This can be done either through his own admission or an analysis of blood or urine may show what drug he has taken.

The prosecutor must also prove that the driver intended to be intoxicated; and that he knew the drug would impair his driving; and that the driver knew he was intoxicated before and during driving.

Sometimes, but not very often, the result of the drug analysis will be used to show that the driver has been a risk in traffic. It is very difficult for the prosecutor to prove the relationship between drugs and hazardous driving and consequently very few persons are convicted of being unfit to drive due to an overdose. Naturally, though, the use of narcotics such as CNS stimulants when injected intravenously, is, as a rule, considered enough for a conviction.

Thus, the main purpose of analysis is to prove consumption of certain drugs which can intoxicate, at least by overdosage. The drug identification is thus essential. However, as pointed out below in the section dealing with the pharmacological and clinical viewpoints, we cannot draw any conclusions from our results which can be of help to the prosecutor; neither can we answer questions concerning the quantity taken. Tables VIII and IX show some of the results of drug analysis.

TABLE VIII *Some Examples of Cases of Barbiturate Intoxication – 1973 and 1974*

Reason for blood sample	Age	Sex	Drug in mg/100 ml whole blood	Problem
Unsteady drive	32	f	0.7 Vinbarbital Aprobarbital	Suicide ?
Accident partly unconscious	54	m	1.2 Pentobarbital	Insomnia
Accident	55	m	1.1 Vinbarbital	Insomnia
Accident	68	m	1.4 Vinbarbital	Neurosis
Accident	58	m	0.4 Pentobarbital	Neurosis
Unknown	44	m	2.0 Phenobarbital	Suicide ?
Accident	64	m	1.3 Phenobarbital	Neurosis
Accident	34	m	0.6 Pentobarbital	Depression
Accident	35	m	0.6 Aprobarbital	Alcoholic
Accident	27	f	1.7 Phenobarbital	Depression

TABLE IX *Some Examples of Benzodiazepin-derivative Intoxications – 1973 and 1974*

Problem	Reason for blood test	Age	Sex	Drug, mg/100 ml
Psychiatric problem	Accident	39	m	0.9 Valium, u.
Nervous problems	Peculiar driving	30	m	0.05 Valium, u.
Nervous problems	Accident	43	m	0.4 Oxazepam, u.
Stomach trouble	Accident	21	m	0.7 Nitrazepam, u.
Stomach trouble	Accident	19	m	0.2 Valium, u.
–	Accident	62	m	15 Nitrazepem, u.
Nervous disease	Wrong side of the road	26	m	0.1 Oxazepam, b.
Epilepsy Alcoholism	Accident	30	m	1.2 Valium, u.
Gall Trouble	Unsteady driving	55	m	15 Oxazepam, u.
Nervous trouble	Accident	35	m	30 Oxazepam, u.
Nervous trouble	Accident	21	m	(0.3 b. (30 Oxazepam, u.
Nervous trouble	Control	26	m	0.4 Valium, u.
Nervous trouble	Unsteady driving	51	m	(0.1 b. (2.0 Valium, u.

u = urine
b = blood

Protocol of the Doctor's Examination

The evidence presented by a doctor is probably the most important proof in court, even more important than the drug analysis because, even if the doctor does not find positive symptoms of intoxication it is next to impossible for the prosecutor to secure a conviction.

The tests the doctor uses follow the pattern used all over the world for this type of investigation. The protocol starts with questions about diseases, alcohol and drug consumption, and statistics concerning weight, height and general condition of the driver. Then follow some observations by the doctor concerning tests of the motor and psychological functioning of the driver, such as eye reflexes, color of face, walking, gait in turning, Romberg's finger to finger test, speech, and ability to count backwards. The doctor ends with a conclusion about the degree of intoxication. Doctors tend to be familiar with symptoms caused by drug overdosage and very often it is possible from the positive symptoms and the doctor's comments to get an idea of the type of drug the driver has taken. As a rule the protocol is in good agreement with the opinion expressed by the police about the condition of the driver, in contrast to cases where only alcohol is involved.

FACTORS CONCERNING ANALYSIS

Preliminary Screening of the Sample for Drug Analysis

As the alcohol is usually imbibed at parties, bars or restaurants, many of the intoxicated drivers found in an evening will be moderate social drinkers on their way home. It is rare that this type of person mixes drink with drugs (unless it is with cough mixtures, acetylsalicylic acid or antihistimines).

Several investigators have shown that misusers are, as in other countries, another category. More than half the drunken drivers we know of are heavy drinkers. To be able to drive a car with a high BAC a person must be very used to alcohol. Many of these drivers have never been able to get a driver's licence or else their licences have been withdrawn. It is in this group that we mostly find that alcohol and other drugs have been taken together. Nervous diseases are very common among such persons and they consume large amounts of psychopharmacalogical drugs and sleeping pills and thus their tolerance for alcohol goes together with a tolerance for other drugs. In all, they are in poor health and are prescribed various types of medication that may impair their driving skill and strengthen or add to the impairment caused by alcohol.

We receive about 800 blood samples a year which are analyzed for alcohol and other drugs. If the doctor who examined the driver is not sure whether symptoms of intoxication are due to alcohol or drugs he often, besides the Widmark capillaries, collects 10 ml of blood.

When the samples arrive at the laboratory we first examine the blood for alcohol. If a reasonably high BAC is found, the blood is not analyzed for other drugs. The reasons for this are as follows: if the prosecutor can prove through witnesses or the doctor's examination that the driver was unfit to drive a car and, if he can further prove he was drunk by the alcohol analysis, no analysis of other drugs is needed. Nor is it required if the prosecutor is able to prove that the BAC at the time of driving was above 0.15%. If it happens, however, that an analysis of other drugs is also asked for to strengthen the case, the punishment is still the same, a jail sentence and loss of the driving licence. Also, if the BAC is between 0.05% and 0.15% and if the prosecutor is convinced that it is impossible to prove that the driver was intoxicated and get a conviction on those grounds, he will not have any use for a second-degree offence.

We are then left with the relatively few samples from drivers who have taken only drugs other than alcohol. They number about 200 a year and in 1974 only about 160 are expected. Nearly one third are samples from persons using intravenous injections of substances that stimulate the CNS. From an analytical point of view these offer little difficulty.

Finally, we must consider the remaining cases; usually about a 100 a year. In Sweden, an M.D. must take the blood sample and examine the suspected drunk driver. (It is the duty of all doctors, private practitioners excepted, to help the police when requested.) The doctor takes a blood sample and examines the driver for symptoms of intoxication. During the clinical examination the driver often tells about the drugs he uses. If there is no information in the doctor's record, the police are asked to investigate, and with this information as a basis, the type of analytical technique is decided. A great deal of analyses are done in vain as less than half of the cases are ever brought to court.

In most cases where a driver has taken a real overdose of drugs, he is suffering from some serious disorder: it may be a suicide situation, a deep depression, sudden anxiety, or some other psychic disturbance. Thus, even if he is not charged with any crime, measures are taken to prevent a repetition.

There are a few persons who have taken drugs over a long period of time. These drugs accumulate in the body. Sooner or later some of these drugs cause some individuals to become too intoxicated to drive safely and they are therefore involved in accidents.

This procedure of eliminating analysis may be changed in the future and the court may eventually take into consideration the combined effect of alcohol and other drugs. However, a great deal of research must still be done before the law can be revised.

Some Pharmacological and Clinical Points of View

Almost all drivers who mix alcohol with other drugs are alcoholics or have misused alcohol or other drugs over a long period of time. Their liver metabolism, digestive system, and many other functions are more or less abnormal. We know that these abnormalities can change the metabolism and the effect of drugs and that along with the misuse a high tolerance develops. The reason for this is not known but one explanation might be that the receptor site is less sensitive.

Normally this tolerance is followed by a more rapid metabolism of alcohol. Also, with tolerance the drug user will increase the amount he takes. It is a general clinical observation that one must give large amounts of drugs in the beginning of the hospitalization of misusers to get a therapeutic effect and then gradually reduce the dose as the liver becomes more normal.

There is no definite relation between the concentration of a drug in the blood and the therapeutic effect – even if we determine the free and the bound drug – and the concentration in the blood does not give any information about the situation at the receptor site.

It is also impossible to define a level above which the concentration must be considered a toxic dose and there is no given relation between the amount of drug consumed and the blood level. A therapeutic dose may be 1 μg/ml of blood for one person and 2 to 3 μg/ml or more for another; even greater variations are common. Thus it is very difficult in the case of most drugs obtained from a blood concentration to discuss the amount consumed and effect of the drugs on the driver's skill.

The above observation refers to experiments with human subjects who are considered normal. The position is even more complicated when we are dealing with alcoholics or drug abusers with all their abnormalities, including those of the receptor sites. With these persons we also do not know the time or quantity of the consumption. Also, there is no way of telling how long the consumption has been going on with the resultant loading of the liver with drugs.

Since the parent drug is usually the pharmacologically active one, it is important that the unmetabolized drug should be identified, and for this reason we always check our result with gas chromatography-mass spectometry in cases brought to court.

There are exceptions where the metabolites are the active ones; but today we hardly know enough about drug metabolism to try to isolate them and draw conclusions from such results. Metabolites may be as pharmacologically active as the parent drug. On the other hand, they may be inactive but block the receptor site for the parent drug or for some other substances and be directly toxic to the tissue.

Conclusions drawn from a blood analysis about a driver's impairment are thus limited. Other circumstances must be considered including the driving, the police observations, witnesses, the doctor's examination, the disease involved and finally the result of the analysis that could at least give a reason for the symptoms of the intoxication. The prosecutor and the Court thus seem to be correct in not paying too much significance to the drugs taken when the alcohol level is sufficient to get a conviction.

The situation is very complicated and no expert would be able, in an individual case, to separate the effect of alcohol from that of other drugs or to state that the drugs alone must have made the driver incapable of driving. This also means that one cannot, with any certainty, by means of a drug analysis from a person killed or injured on the highway, claim that the amount of drug found caused the accident. Problems such as these arise in insurance cases and are settled before civil courts. It is of course important for a physician to know if drugs have been mixed with alcohol so that the correct medical treatment can be provided.

Program for Analysis of Drugs in Blood and Urine

The procedure must be judged in accordance with what has been said about the value of the analysis for the prosecutor and the Court. In Figure 1 the outline of our procedure is shown and the drugs most commonly found are listed in Table X. It is a conventional extraction procedure dividing the drugs into acid, neutral and alkaline fractions. The method has been used for the past five years with only minor modifications. However, the technique used to analyze the chloroform solution changes with time, and a few years ago we started using gas chromatography-mass spectrometry.

As mentioned above, it is generally known which substance to look for and this leads the analysis in a certain direction. Usually a urine sample is available and is analyzed first, giving further information about the drugs present and also some idea about the amount to be expected in the blood. It is not a screening procedure although the substances marked X will be discovered during the spectrophotometric assay. As shown in Table V, the drugs usually consumed by drivers are very well covered by this procedure.

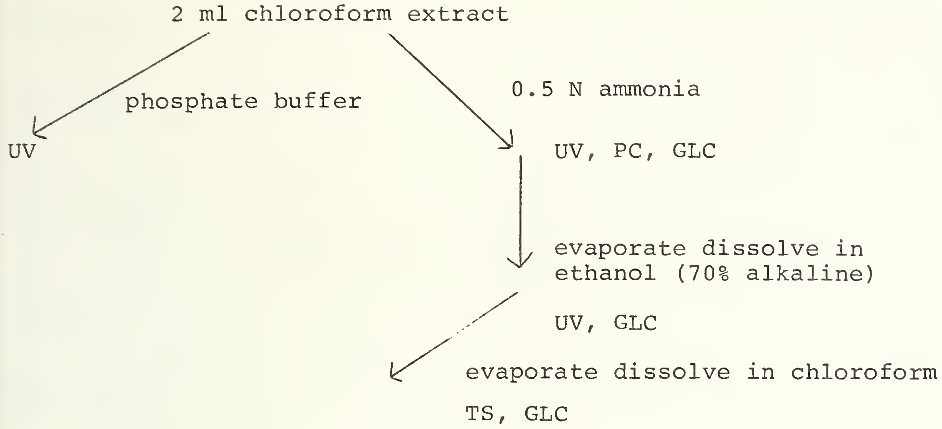


Figure 1 *Standard procedure: Five to ten ml of whole blood or urine are extracted with chloroform at about pH 2-3. The organic phase is carefully evaporated and the residue dissolved in hot weak hydrochloric acid. Most of the fat is separated by cooling the solution and filtering. The solution is again extracted with chloroform which is evaporated to a small volume and transferred to a five ml flask.*

UV = ultraviolet spectroscopy
GLC = gas liquid chromatography
TS = thin-layer chromatography
PC = paper chromatography

TABLE X *Examples of Drugs Found in Blood and Urine*

Blood		Urine
UV and GLC	TS, GLC	Special analyses
barbiturates	meprobamate	central stim.
salicylic acid	hexapropymate	phenothiazines
phenylbutazone	phenprobamate	tricyclic amines
oxyphenbutazone	glutethimide	alkaloids
chlorzoxazone		chlorinated volatile
methaqualone		organic compounds
phenazone		aromatic hydrocarbons
caffeine		hémineurine
methyprylon		benzodiazepine

UV = ultraviolet spectroscopy
GLC = gas liquid chromatography
TS = thin-layer chromatography
PC = paper chromatography

It is not worthwhile to use flamephotometry, atomic absorption spectrophotometry or immunoassays as only very few samples need these methods, and an instrument and a method would have to be in operation every day to prevent preliminary experiments from taking too long. In this connection one should not forget that 25 years ago forensic chemical laboratories were almost the only ones doing drug analyses, at least qualitatively, and that today many other laboratories are involved; a great many of them with far better facilities than most forensic ones.

Whenever possible the material is divided into two parts, one for a preliminary analysis and the other to identify the substance by gas chromatography-mass spectrometry – if the prosecutor wants to go to court with the case.

The benzodiazepines are a problem at present. The parent drug is not isolated but the diazepines are converted into the corresponding benzophenone before being extracted and analyzed. This means that not all the diazepines on the market can be identified. The benzophenones of diazepam and nitrazepam can be separated from N-desmethyl-diazepam, chlordiazepoxide and oxazepam by thin layer and gas chromatography. Otherwise the procedure is thoroughly worked out and every step strictly controlled so that a technician can carry out the analysis without difficulty.

The chloroform extracts can be submitted to various analytical techniques such as GLC with different columns, fluorometry or gas chromatography-mass spectrometry using fragmentography if necessary. The special methods mentioned in Figure 1 refer mainly to different extraction procedures. Spectrophotometry, gas liquid chromatography (GLC), and to some extent fluorometry, are methods that even a technician can use without too much control.

Immunoassays are methods that must be handled with care and the very small amounts of drug that can be determined demand a very 'clean' laboratory and a staff trained in immunology. These methods are not absolutely specific or quantitative. For screening they are excellent but unfortunately expensive. The best instrument today seems to be the GLC-MS instrument but it also requires very skilled technical and scientific personnel to keep it working on a regular basis.

SCIENTIFIC PROGRAM CONCERNING DRUGS AND DRIVING

Research

A scientific program must comprise applied research to some extent. However, no laboratory can survive without doing basic research and to accomplish this a firm connection with the universities must exist. Little work has been done on the development of tolerance to alcohol and drugs and its connection with driving and traffic accidents. A person who starts being drunk at a BAC of 0.05% needs a much higher level (for example, 0.2%) after a few years of drinking to show the same degree of intoxication and to get the same satisfaction from his drinking. This applies to other drugs as well. Usually people drink until they reach their tolerance level which can be as high as 0.3%. A drinking pattern that goes beyond the tolerance level is mostly seen with pedestrians; drivers usually sober up, at least to some extent, which means that their alcohol level decreases. As for consumers of other drugs, they will take as many drugs as are needed to get the desired effect, and this amount increases as the tolerance develops. Most studies testing the effect of alcohol and other drugs on driving skill have not considered this tolerance as students or policemen are usually used as subjects in experiments.

The effect of alcohol and drugs separately and in combination should be studied using people with a high tolerance to both. Also, the experiments should take into account that, with time, in the 'real life' situation, the alcohol and drug levels decline in the blood. In spite of the pure relationship between the level of the drugs in the blood and the pharmacological effect, at least a urine test should be done to make sure that the drug has actually been resorbed. Every year many papers appear with new methods for the determination of the presence of drugs, indicating that no method so far published is perfect. Too little interest has been paid to making a complete extraction of drugs and their metabolites from biologic material. The procedure should also protect the technicians from infection and as little organic solvent as possible should be used in order to avoid poisonous concentrations in the air. At present our laboratory is trying two ways to achieve this; one is to extract with 70% ethanol and the other is to go back to Soxhlet's apparatus using ethanol for the extraction.

For the gas chromatograph-mass spectrometer instrument, many new ways of treating the samples before analysis have been suggested, such as injecting blood and fractions of organs directly into the gas chromatograph. Also mass fragmentography and chemical ionization mass spectroscopy are now widely used. Work has been done, and is in progress, in many places to identify all the normally occurring substances in blood and urine in order to make it possible to eliminate them by a computer system.

Concerning other programs, the use of enzymatic hydrolysis of urine compounds of drugs can be mentioned. The metabolites of many drugs inhibit β-glucuronidase and after a period of hydrolysis, the free metabolites must be removed in order to get all compounds free. The diazepine metabolites are especially strong inhibitors of the enzyme. We are studying this reaction closer because *in vivo* the metabolites of certain drugs might inhibit the formation of glucuronides.

International Collaboration and Education

So many things differ from nation to nation but all have two main problems in common: 1) ascertaining the effect on highway safety of alcohol and other drugs, separately or in combination; and 2) preventing people from driving while impaired by drugs or alcohol.

New studies on the effect of alcohol and drugs on human beings should be performed and the experimental conditions should be examined by experts representing many different disciplines. The study conducted in the U.S.A. by Borkenstein *et al* (1) and the Toronto study by Lucas *et al* (2) should be replicated under conditions where, at least through a temporary change in the law, all operators in traffic can be examined by "alcotest". It would also be helpful if the studies could be done in countries where it is possible to check relevant information concerning the drivers that dates back ten years. It does not seem realistic to plan a similar study concerning the use of other drugs.

Plans for prevention could be discussed and carried out internationally. In Sweden the present law allows a person to drink an average of 50 grams of alcohol 4 hours prior to driving, and it allows one to drive under the influence of a therapeutic amount of drug and also to drive in spite of the disease that required the prescription. However, as noted above, the physician must warn the patient that the medicine could impair his driving and also tell him not to combine it with alcohol. Warnings are continuously sent out to doctors about certain drugs and the risk of misuse, to admonish them not to prescribe too much medication at a time, and to control the patient's consumption. The drugs that can impair the driver are marked with a warning.

The danger of alcohol and other drugs as regards traffic safety is also taught in schools and in the course one must take to obtain a driver's license. Now and then warnings are sent out on television, radio and through newspapers.

In Sweden 1975 is the "alcohol and drug free traffic" propaganda year. Perhaps something similar could be arranged on an international level, with the backing of a body such as the World Health Organization.

CONCLUSION AND SUMMARY

The consumption of alcohol and drugs is one of the many causes of impaired driving skill. We must realize that mood is also an important factor. Then too, many persons have some kind of disease that in itself, or by the drugs prescribed, can be a danger to highway safety. It is quite impossible for drivers to be at their best whenever they use a motor vehicle. Punishment and even intensive police control cannot put a stop to the presence of alcohol and drugs in drivers.

We cannot forbid people to drive because they happen to be ill and use medication. One can only teach them about the effect of drugs to make them fully realize the danger they are to themselves and others in traffic.

People misusing drugs other than alcohol often hardly know what they are doing at time of driving; they may also be unaware that they are intoxicated by drugs if the process has been going on for some time. It seems difficult to take measures against such persons but fortunately they are a minority in the group of problem drivers.

Many drivers coming home from parties will, as mentioned, put off their driving until they *feel* sober. They also try to drive carefully in order to avoid attention. Also, many individuals who have a high consumption of alcohol and/or other drugs do not realize that they still have some quantity of these in their blood the next morning. Therefore, in my opinion, "alcotest" should be available at every gasoline station, for the sake of at least educating, if not detecting drinking drivers.

There is a risk that authorities pay too much attention to alcohol and drugs and put off all other measures that can be used to prevent accidents such as speed limits, better roads and motor vehicles. We are all fallible and must accept that we are all capable of suffering some impairment at some time during our lives. We should therefore be prepared for such situations.

REFERENCES

1. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., and Zylman, R., *The Role of the Drinking Driver in Traffic Accidents.* Dept. Police Admin., Indiana University, Bloomington, Indiana, 1964.
2. Lucas, G. W., Kalow, W., McColl, J. D., Griffith, B. A., and Smith, H. W., Quantitative Studies on the Relationship between Alcohol Levels and Motor Vehicle Accidents. *Proceedings of the 2nd International Conference on Alcohol and Road Traffic*, Toronto 1955, pp. 139-142.

A Historical and Experimental Study of the Breath/Blood Alcohol Ratio

A. W. Jones[1], B. M. Wright[2, 3] and T. P. Jones

Although breath alcohol analysis has been used for the determination of blood alcohol concentration for more than 40 years, the relationship between the breath and blood alcohol concentrations is still uncertain. For this reason, while the blood alcohol level is now almost universally accepted as a reliable indicator of intoxication, breath is still frequently regarded as only suitable for a screening test. The obvious advantages in convenience and acceptability of breath testing have nevertheless led some countries to adopt it as a substantive test, and most other countries would do so if only the relationship between the breath and blood levels were more clearly established and shown to be sufficiently constant for practical purposes.

HISTORY OF THE BREATH/BLOOD ALCOHOL RATIO

When examining the history of breath alcohol analysis one must remember that it has probably never been studied for its intrinsic scientific interest. The object has always been to find a simple and convenient way to determine the blood alcohol concentration. For this reason the work done and the conclusions drawn have often been influenced by considerations which were scientifically irrelevant though thought to be important from a forensic or commercial point of view. Workers in this field have seldom had sufficient knowledge of physiology or physical chemistry to appreciate fully the complexity of the problem. As a result, although there is a massive literature going back 100 years, very little of it is of any real value. Therefore in summarizing the literature we shall consider only the most significant contributions to the subject.

Although Dubowski (9) has traced the history of breath alcohol analysis as far back as 1874, its first practical use was by Bogen in 1927 (2). Bogen also made some comparisons between urine and breath and concluded that the breath/urine ratio was

---

[1] Formerly of the University of Wales Institute of Science and Technology, Cardiff, U.K., now at the Department of Alcohol Studies, Karolinska Institute, Stockholm, Sweden.

[2] Clinical Research Centre, Northwick Park Hospital, Harrow, U.K.

[3] The investigations described in this paper have been carried out over a period of 4 years. During this time we have had the benefit of consultations with many colleagues at the University of Wales Institute of Science and Technology and at the Clinical Research Centre for which we are most grateful. We are indebted to the Department of Medical Illustration of the Clinical Research Centre for preparing the figures.

about 1 : 2000. The first serious quantitative studies of the breath/blood relationship, however, were made by Liljestrand and Linde (27) in 1930. Although their work is regularly quoted and the breath/blood ratio they arrived at is similar to that used today, the limitations of technique available at that time make their findings of very little evidential value. Nevertheless, they had a clear appreciation of the underlying physico-chemical and physiological factors involved, and laid the foundation of all the later work by putting forward the following basic concepts:

1. The breath sample must be of "alveolar air", as defined by Haldane and Priestley (18) *i.e.* collected after at least 500 ml of breath have been discarded, to avoid dilution with dead space air and give a substantially constant CO_2 concentration.
2. Breath is equilibrated with the blood in the alveoli at about 37°C but its alcohol content, when collected from the mouth, is less than it was in the alveoli, due to re-equilibration at a lower temperature in the upper respiratory tract, so that the actual alcohol content will depend on expired air temperature.

Harger, in 1931 (19) in a communication to the American Chemical Society, suggested an entirely new approach. The report, which is very brief, reads in part as follows:

> *Previous attempts to estimate the concentration of alcohol in the body by analysing the breath have given quite erratic results. This is probably because the breath analysed was not always air from the alveoli or air cells, in which exchange of oxygen and carbon dioxide between the blood and the lungs takes place. By the new method the alcohol and carbon dioxide content of the breath are determined simultaneously. Since the carbon dioxide content of the air is constant, this gives a means of estimating the alveolar alcohol in any sample of breath.*

Although it was based on the nonphysiological assumption that the CO_2 content of alveolar air is constant, and ignored cooling of the breath in the upper respiratory tract, which reduces its alcohol but not its CO_2 content, Harger's method came into wide use in the form of an instrument called the "Drunkometer". A full account of this instrument was published in 1938 (20). Meanwhile in 1934, Haggard and Greenberg (16) had repeated Liljestrand and Linde's work and, in an apparently faultless study, made detailed determinations of the air/water and air/blood alcohol partition ratios. Unfortunately, for some reason that has never been satisfactorily explained, they obtained completely erroneous results. They concluded, quite differently from the air/water studies of all previous workers, that the breath/blood alcohol ratio was 1: 1300 at 34°C and not 1 : 2000 at 31°C as suggested by Liljestrand and Linde. Harger and his associates also believed the breath/blood ratio to be about 1 : 2000 and they vigorously attacked Haggard and Greenberg's findings. In 1941 Haggard and Greenberg (17) revised their previous findings and put forward a ratio of 1 : 1600 at 34°C. In the same year Greenberg and Keator (15) described a new breath alcohol device, the "Alcometer", which analysed "alveolar air" for alcohol and took no account of CO_2.

There then followed a prolonged and acrimonious controversy between the Yale School, represented by Haggard and Greenberg, and the Indiana School, represented by Harger and his associates, about the use of the CO_2/alcohol ratio and the correct figure for the breath/blood ratio for alveolar air. In 1950 Harger, Raney, Bridwell and Kitchel (22) published an extensive study of the *in vitro* air/water and air/blood partition ratios for alcohol and obtained air/water results that agreed well with those of all previous observers except Haggard and Greenberg. Their air/blood results also differed somewhat from those of Haggard and Greenberg. In the same year Harger, Forney and Barnes (21) published the results of a study of alcoholic breath by four methods, alveolar air, rebreathed air, alveolar air using the alcohol/CO_2 ratio, and mixed expired air using the same method. They also measured the temperature of expired air, and noted that it rose from 31 to 35° during prolonged expiration, which was in accordance with the findings of a number of previous investigators. Their results for a simple analysis of alveolar air, defined by them as breath delivered after 600 ml had been discarded, showed a considerable scatter with a mean breath/blood ratio around 1 : 2100 at 34°C. The results for rebreathed air, which they considered to be essentially the same as alveolar air, were similar. Breath/blood correlations for alveolar air and mixed expired air, using the CO_2 method, were also similar, but none of the correlations would now be considered good enough for anything but a screening test.

The controversy ended in 1953 when a special committee appointed by the U.S. National Safety Council issued the following statement:

> *The basic principle governing the operation of the three presently used breath alcohol methods (the Drunkometer, the Intoximeter, and the Alcometer) is the constant ratio existing between the concentration of alcohol in the alveolar air and the blood.*
>
> Available information indicated that this alveolar air/blood ratio is approximately 1 : 2100. *However, since each method involves different procedures, different empirical factors are involved in the calculation of concentrations of alcohol in the blood in each of the methods.*

The "Drunkometer" CO_2 method was finally abandoned about 1960, after Smith (34) made a vigorous attack on the CO_2 principle and showed that reliance on the fixity of the alveolar CO_2 produced more errors than it avoided. The "Intoximeter", which originally operated on the same principle as the Drunkometer, changed over to the use of alveolar air and still survives. It has also given its name to a portable gas chromatograph made by the same company.

The "Alcometer" was succeeded by the "Breathalyzer" which survives to the present day. It has been frequently copied and has become universally accepted throughout the world and has given its name as a generic term for all breath alcohol analysers in the U.K.

The Breathalyzer

This instrument was developed by Borkenstein in about 1950, although a full description was not published until 1961 (3). It used a new and original photo-electric principle, as well as a new method of collecting end-expired air, both of which have remained unchanged, except for some minor details, to the present day. In view of its great practical importance the instrument is worth considering in some detail. The subject blows through a warmed flexible tube into a heated metal cylinder with a free piston which is raised until his breath escapes through side ports. When he stops blowing, the piston drops a short way, closes the ports and trapes a volume of 52.5 ml. When the piston is released the breath sample is bubbled through a potassium dichromate and sulphuric acid solution in a glass ampoule. The decolorisation of the solution by the alcohol is measured photo-metrically, and the result can be read off on a scale calibrated in blood alcohol units. Borkenstein accepted unquestioningly the correctness and fixity of the 1 : 2100 ratio and his instrument was designed specifically the conform to it, even the cylinder volume of 52.5 ml being 1/40th of 2100. It was therefore always difficult to explain why, in practice, the instrument gave substantial variations in the breath/blood alcohol ratio and also tended to read on the average 10-15% low.

When considering the sources of error in the Breathalyzer it is essential to realize that, although ostensibly calibrated *a priori*, the Breathalyzer is in fact calibrated *a posteriori* by means of an "equilibrator", because the analytical performance of the instrument is influenced by a number of factors which cannot be precisely controlled, and each instrument's sensitivity has to be adjusted during manufacture while its calibration must be checked for each ampoule.

The equilibrators used are based on the method, employed by Harger, of bubbling air through a mixture of alcohol and water of a suitable concentration at a controlled temperature. Wright (37) criticised this method on two grounds: (a) it is very difficult, if not impossible, to produce complete equilibration by bubbling; (b) it is impossible to avoid the production of a liquid aerosol, due to the bursting of the bubbles, and the subsequent evaporation of the aerosol can lead to super-saturation, or the droplets can even be carried over into the analyser.

In practice, the first criticism, to some extent, tends to be cancelled by the second, but the performance of an equilibrator of this kind is critically dependent on its design, and on the rate of gas flow through it. Moreover, with a temperature coefficient of 6.5% per °C (12) the solution and the gas need to be temperature-controlled to better than 0.5°C to obtain even ± 5% accuracy. Commercial equilibrators commonly operate at 34°C, which can lead to appreciable condensation of the vapour in the head space and connecting tubes if the device is used in a cool room. Moreover, the air is usually supplied from a hand bulb, and is therefore at room temperature. Wright therefore advocated, instead, the use of dynamic mixing of alcohol, water and air in known proportions to produce artificial alcoholic breath for absolute calibration purposes.

The question of calibration, however, concerns only the analytical accuracy of the Breathalyzer; it is equally important to consider its ability to collect a suitable breath sample. Wright pointed out that, although the Breathalyzer contained an effective end-expired breath sampler, the type of sample obtained depended on the reliability of the operator and the co-operation of the subject; since the sample could be taken after as little as 100 ml had been discarded or after a full expiration, it could be anything from dead space air to an end vital capacity sample. In 1950 Harger *et al* (21) pointed out that, since final equilibration takes place in the mouth, at temperatures which can vary from 32° to 35°C, the high temperature coefficient of the partition ratio could produce variations of ± 10% in the breath/blood ratio. Wright (37) suggested that, as a result of this temperature effect, since it was known that the breath temperature rose continuously during expiration, the breath alcohol concentration would also be expected to rise in the same way. Using a special flame ionisation detector without a column, he showed that it did appear to do so, and that the rate of rise differed between subjects, so that it could produce variations between subjects in the breath/blood ratio, even if the same discard volume were used.

Also in 1962, Kitagawa and Wright (26) described a new breath analyser which was based on the same fundamental sampling principles as the Breathalyzer, but designed to be cheaper to make and easier to use. This analyzer incorporated an automatic device which compelled the subject to discard 500 ml of breath before the instrument would operate, and made use of a special detector tube (25) to estimate the alcohol content of the breath.

The Breathalyzer has been widely used in scientific work on the effects of alcohol on human personality and behaviour, especially in relation to driving (4), so it is unfortunate that the exact calibration of the instruments used has usually not been known. Nearly all early studies of the reliability of the Breathalyzer were vitiated by presenting no evidence of the reliability of the blood analysis, by not taking duplicate breath or blood samples, and by not taking sufficient care to make blood/breath comparisons only when absorption and distribution of alcohol were complete, so that there was no arterio-venous difference.

In 1964 the first fully satisfactory study of the accuracy and precision of the Breathalyzer was made by Begg, Hill and Nickolls (1). The blood analyses were blind duplicated and no comparisons were made until serial breath analyses showed a steadily falling level, indicating that the absorption and distribution were complete. Begg *et al* found the Breathalyzer to read, on the average, about 13% low and to have 1% confidence limits of ± 16% for the estimation of the blood alcohol from the breath (38).

These results were in line with those of most previous investigators, but for the first time they were unequivocal. At the same time it must be noted that, although their observations of precisions are probably valid for all instruments of the same type, (subject to operator performance, which may have considerable importance), the −13% figure is valid only for the particular instrument they used.

At the Indiana Conference in 1965, Enticknap and Wright (11) described the results of another attempt to determine the *in vivo* breath/blood ratio, using the Kitagawa-Wright analyser. The instrument was calibrated on artificial alcoholic breath generated by dynamic mixing to conform to the 1 : 2100 ratio at 34°C. Thus the precision and accuracy of the breath method were established as an integral part of the experiment. Breath samples were taken in duplicate, one before and one after each blood sample. Blood samples were taken from indwelling intra-arterial or intravenous cannulae and were analysed blind in duplicate. Only two subjects were studied, each on two occasions, but it was possible to draw the following conclusions: (a) both subjects had mean breath/blood ratios well below 1 : 2100, one being 1 : 2370 and the other 1 : 2580; (b) these ratios were consistently different for the two subjects; (c) both subjects showed sudden changes in breath and blood alcohol concentrations which caused temporary changes in the ratio. In spite of the relatively (by modern standards) imprecise methods of blood and breath analysis, these sudden deviations were probably real because the duplicates of both breath and blood showed good agreement. Enticknap and Wright (11) therefore concluded that the ratio was more variable and lower than commonly supposed, and suggested a mean figure of 1 : 2370 on the best available evidence, which they considered was that of Begg *et al* (1).

At the same conference, Fox *et al.* (14) gave the results of a meticulous breath/blood comparison, using the Breathalyzer, and found it to read about 12% low, in spite of great care being taken to sample after a full expiration.

In 1966 Payne *et al.* (30) created considerable confusion by publishing the results of a breath/blood correlation study which appeared to show a non-linear relationship, the breath alcohol falling relative to the blood at higher blood levels, and concluded that, due to the wide variations in the breath/blood relationship breath analysis was virtually excluded as a method of determining the blood alcohol. It was pointed out editorially however (5), that "this sweeping statement was counter to almost all the evidence adduced by other workers". Their findings have never been confirmed and may have been due to the use of an unreliable infra-red analyser for breath.

At the Freiburg Conference in 1969 Franklin (13) published the results of careful studies of the Breathalyzer in which she found the ratio to be 1 : 2300, and Noordzij (29) at the same conference, using the "Ethanograph", which works on the same principal as the Breathalyzer, found the ratio to be 1 : 2350.

Up to this time, however, all observations could be criticised on the ground that the chemical analytical methods used were too imprecise to determine the ratio with sufficient certainty to establish that the difference between 2100 and 2300 was really significant.

In 1966 Curry, Walker and Simpson (8) described a method of blood alcohol analysis by gas chromatography, using an internal standard, and the modern era of blood analysis, with standard deviations from 1 to 2 mg began, but it was not until 1969 that similar precision was obtained with breath alcohol analysis on a practical scale, when Penton and Forrester published their account of the Gas Chromatograph Intoximeter (32).

In 1972 a meeting was convened at Indiana University to consider whether the 1 : 2100 ratio should be revised. After a prolonged argument, the following statement was issued:

> *The basic principles governing the design of breath alcohol instruments is that a physiological relationship exists between the concentration of alcohol in expired alveolar air and in the blood. Available information indicates that 2.1 litres of expired alveolar air contain approximately the same quantity of alcohol as 1 millitre of blood. Continued use of this ratio in clinical and legal applications is warranted.*

This rather colourless statement was a compromise between the advocates of the 2100 and 2300 figures. The use of 2.1 litres instead of 2100 indicated that the ratio was only reliable to two significant figures, and the word "approximately" indicated that the question was still open.

The question is now, however, virtually settled since Dubowski (10), using a very precise infra-red analyser and equally precise blood analysis, and assuming a 1 : 2100 ratio, found the breath to under-read the blood by about 12%, and Noordzij, Harris and Breen have respectively reported similar findings in this volume.

The present work was begun in 1970, the original object being to repeat all the previous classical experiments, using the more precise and rapid methods of alcohol analysis now available to make a definitive determination of the breath/blood ratio *in vivo* and *in vitro,* and to try to explain the apparent deficiency and variability of the alcohol content of the breath.

EXPERIMENTAL STUDIES

Analytical Methods

Alcohol in water or blood. This was determined by gas chromatography, using a Perkin-Elmer flame-ionisation instrument, the water or blood being diluted 1 : 10 with a n-propanol internal standard solution, as described by Curry *et al.* (8), using a peak-height ratio for the determination.

Under closely controlled conditions, taking and analysing the samples in the same laboratory, the standard deviation (SD) of duplicate samples at the 100 mg/100 ml level was 0.4 mg/100 ml for aqueous samples, and 1.3 mg/100 ml for venous blood samples taken from subjects. Repeated analysis of the same blood sample had SD of 0.3 mg/100 ml.

Accuracy was checked with commercially available standard solutions, and also with made-up standards, and was better than 1.3%. Since we were concerned almost entirely with ratios, the absolute accuracy of our methods was not very important, however.

Alcohol in air or breath. This was also determined by gas chromatography, using a Mark II Gas Chromatograph Intoximeter (GCI). In this instrument (32) the subject breathes through a mouth piece which leads to a sampling valve and then to an outlet nozzle, the whole being kept at a 100°C inside the case of the instrument. The outlet nozzle can be fitted with a bag, usually of 1.5 litres capacity, to which in turn a whistle can be connected that indicates when the bag has been filled. Air samples can be injected directly into the sampling valve which takes a volume of 0.25 ml.

Alcohol-in-air standards. The precision of the analysis was repeatedly checked with alcohol-in-air head space samples prepared by static equilibration, as follows. Solutions of alcohol in water of various known concentrations were held in conical flasks with thick rubber caps immersed in a thermostatically controlled, stirred, water bath at 25°C ± 0.05°. At this temperature there is less danger of loss of alcohol by condensation on the neck or cap while sampling. It was found that the alcohol concentration in the gas phase came to a steady level in about ten minutes and forty 5 ml samples could be taken before the concentration had fallen by 1%.

Air/water partition ratio. The alcohol concentration in the gas phase of the equilibrator was checked by re-determining the air/water partition ratio by a new absolute method. A measured volume (about 1 ml) of an alcohol solution of known concentration was placed in a 1 or 2 litre flask and equilibrated at a known temperature. A portion of the solution was then removed and re-analysed. In this way the amount of alcohol lost to the air in the flask was determined and the partition ratio at that temperature could be calculated. The partition ratio at 25°C, determined in this way, was found to agree well with that of Harger (21), which in turn agrees with those of all earlier workers except Haggard and Greenberg (16, 17). It was therefore felt that it was satisfactory to use air samples produced by static equilibration for calibrating the GCI and to determine the partition ratios at other temperatures by analysis of head-space samples.

Multiple analyses of air samples prepared in this way, taken with a warmed 5 ml syringe and injected into the sampling valve of the GCI, has a SD of 0.5 mg/100 ml at a concentration approximately equivalent to blood levels of 100 mg/100 ml.

Blood/breath correlation studies. Having established the accuracy and precision of our methods we used them to make a number of breath/blood correlations, using healthy young male volunteers in the laboratory. The subjects were asked to blow into the GCI for as long as possible, and only when the sound of the whistle showed that the flow was slackening was the sample taken. The exact volume discarded was not measured, but it was never less than 2 litres, and in some cases an end-Vital Capacity sample was taken. Capillary blood samples were taken between two breath samples once absorption and equilibration had been shown to be complete by a steady fall in breath alcohol. The results of 78 such comparisons on 15 subjects are shown in Figure 1.

Three points will be noted: 1. The line of best fit is not 1 : 2100, but 1 : 2300, which is very close to the figure suggested by authors such as Enticknap and Wright (11), by Franklin (13) and by Noordzij (29). 2. The correlation between breath and blood, though good, is not as close as would be expected from the known precision of the air and blood analyses. With SDs of 0.5 mg for alcohol-air mixtures and 1.3 mg for blood, the SD of an estimate of the blood alcohol concentration from the breath should be 1.55 mg but in fact it is 3.4 mg. 3. The mean SD of paired breath samples was 0.85 mg, the range being from 0.6 to 1.1 for different subjects.

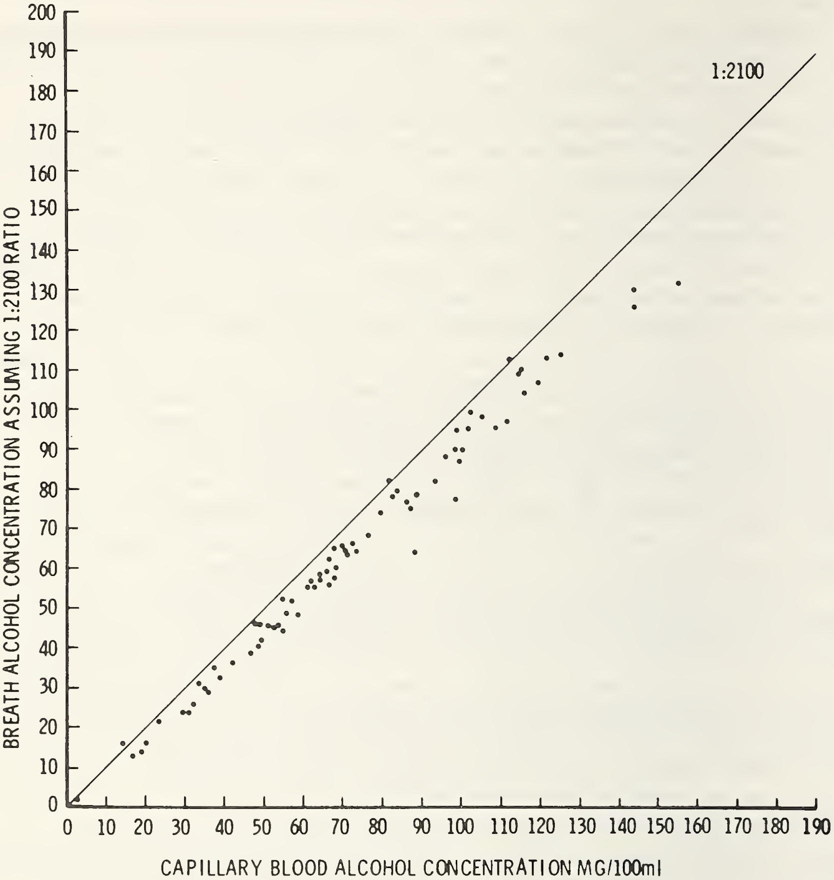


Figure 1 *Breath/Blood correlation study on 15 male subjects, using gas chromatography for both breath and blood.*

These results suggested that the doubts about the precision and accuracy of the determination of blood alcohol by breath analysis, even with such a precise method, were well founded and called for a careful re-examination of the theoretical and practical basis of the procedure. We therefore decided, as a first step, to re-check the *in vitro* air/blood ratio.

In vitro Studies of the Air/Blood Ratio

Methods. Equilibration was carried out as for the air/water standard and the blood and air alcohol concentrations were determined as already described. Most of the work was done on small blood samples kindly supplied by the Welsh Regional Blood Transfusion Unit. Alcohol was added to the samples to produce blood alcohol concentrations usually of the order of 100 mg/100 ml.

The mean air/blood ratio at 34°C was 1 : 2164 (SD 43) for men and 1 : 2208 (SD 45) for women. The difference of 2% between the sexes, which was of high statistical significance, was presumably due to the well-known difference in haematocrit between men and women. The mean of all the subjects is 1 : 2180.

We also determined, in 42 subjects, the temperature coefficient for the ratio from 20 to 40°C. We found it to be nearly constant at 6.3% per °C between 30° and 40°, which agrees well with Harger's figure of 6.5% (21).

Our mean ratio at 34° was, however, 6% lower than Harger's figure of 1 : 2050. This we believe can be largely accounted for by the fact that we used heparin as an anti-coagulant while he used 0.5% sodium fluoride which we have found to raise the vapour pressure of alcohol at this temperature by 5.1%.

It therefore seemed that, although the discrepancy between the *in vitro* and *in vivo* breath/blood ratios at 34°C was rather less than had appeared, it was still substantial. Therefore we decided to make a detailed study of the changes in alcohol concentration in the breath during expiration, in relation to expired volume and breath temperature.

In vivo Studies of Breath/Blood Ratio

Methods. Breath alcohol concentration was measured with the GCI as already described.

Volume was measured with a Wright Respirometer (36) connected to the outlet of the GCI, using both the original mechanical respirometer and also an electronic version (7) with which volume could be recorded on a 2-channel potentiometric recorder.

Breath temperature was measured with a thermistor inserted in the mouth-piece of the GCI and connected to the recorder. The thermistor was calibrated and frequently checked by immersion in three stirred water baths thermostatically controlled at 32°, 34° and 36°C ± .05.

The connections from the respirometer and thermistor to the recorder were taken through switches which were arranged to disconnect them when the sampling button was pressed, so that the exact volume and temperature at the moment of sampling were recorded. A typical record obtained in this way is shown in Figure 2.

Procedure. To overcome the difficulty of a continually falling blood alcohol level, and to avoid the need for possibly erroneous back calculations, the breath alcohol level in a sample taken at the end of a full Vital Capacity (VC) was taken as 100%, and the level after lesser expirations was expressed as a percentage of that in an immediately preceding or following end-VC sample. Samples could be taken and read at two minute intervals so that no significant error due to time lag resulted.

Using this technique it was possible to obtain "alcohol expirograms" from a number of subjects. From these it appeared that although the breath alcohol level was flattening off it had not really reached a constant level by the end of even a full VC expiration and never reached the level predicted from the temperature of the breath at the moment of sampling and the blood alcohol level at the time.

It was therefore decided to use the re-breathing technique of Harger, Forney and Baker (23). In this procedure, the subjects were asked to take a moderate inspiration and then breathe in and out of a plastic bag of about 4 litres capacity. The bag was kept warm in an electrically heated outer bag, but taken out for use. At the end of re-breathing the subject expired into the bag which was then discharged into a modified Drunkometer. Professor Harger kindly loaned us one of his heated outer bags

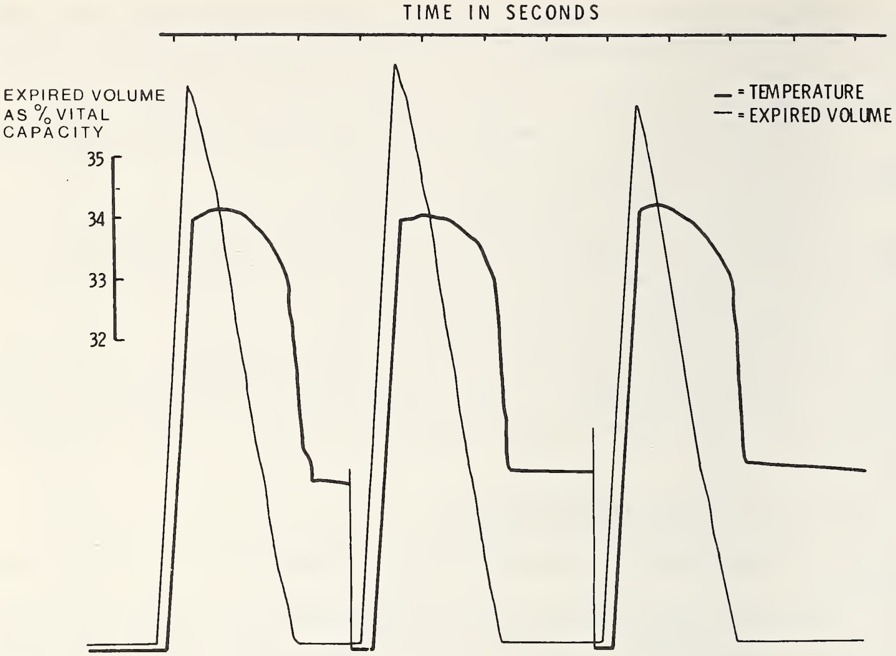


Figure 2 *Record of 3 successive full expirations from one subject. The temperature and volume records were switched off simultaneously at the moment of sampling.*

but we modified his technique. Instead of taking the inner plastic bag out for use, we kept it in the outer bag where its temperature was maintained at 40°C ± 3°. This slight elevation of temperature seemed unlikely to influence the breath temperature because the heat capacity of dry air is very small compared with that of the respiratory tract. On the other hand, loss of alcohol due to water condensation in the bag, though slight, was, we felt, to be avoided if possible.

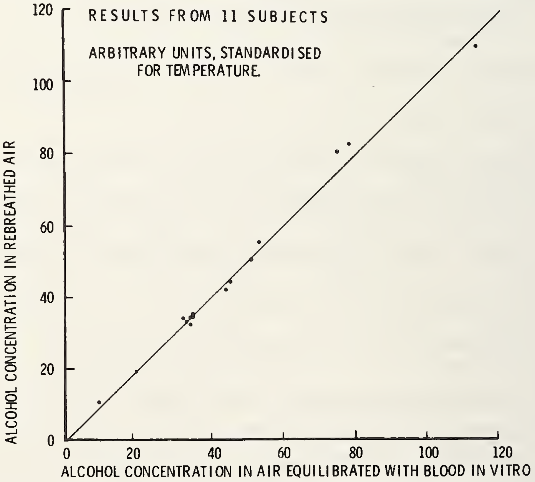


Figure 3 *Correlation between rebreathed air and blood alcohol levels obtained by equilibration* in vitro *in 11 subjects.*

In the second modification the subject expired directly into the GCI after taking his last breath from the bag, instead of sampling from the bag. In this way, the breath temperature could be recorded, which was not possible using Harger's original method.

The first observation we made was that the re-breathed air alcohol concentration (RBAC) was, as already noted, substantially higher than that of an end-VC sample. Secondly, when re-breathed air was compared with air equilibrated over a sample of the subject's blood taken at the same time and held at the same temperature, the two alcohol levels were found to agree very closely (Figure 3). We therefore decided to call the RBAC 100%, and to do expirograms with up to five re-breathings to allow us to see the complete pattern of alcohol change during the procedure. To measure the volume expired during re-breathing, a second (mechanical) respirometer was inserted in the bag. Each sample taken after less than five rebreathings was paired with a five re-breathing sample, as was done previously with the end-VC samples. Figure 4 shows the results on six subjects where breath temperature and alcohol level are plotted against expired volume. Volumes above about 5 litres were, of course, only reached by re-breathing, as shown by the discontinuity in the curve at this point.

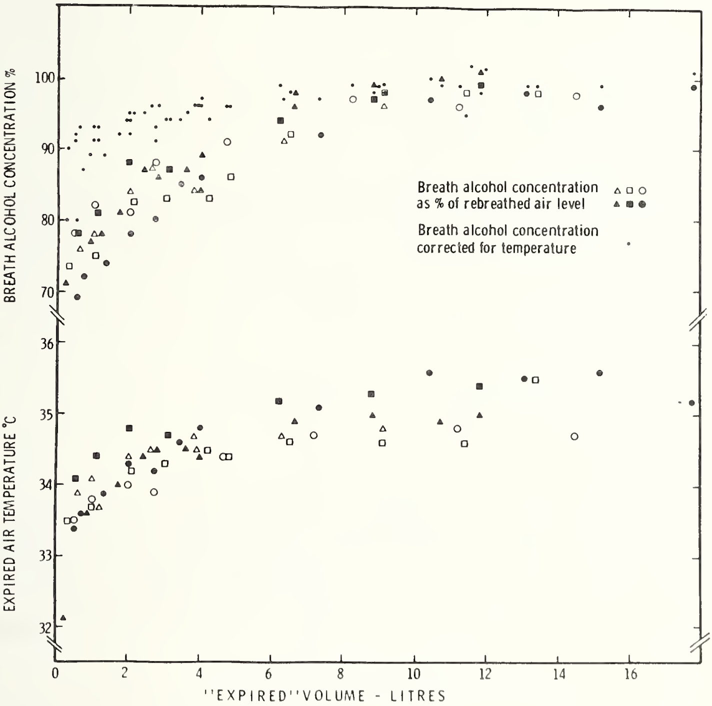


Figure 4 *Alcohol expirogram for 6 subjects.*

The breath temperature rises very rapidly to about 34° and then more slowly, to reach a plateau at about 35° after 2 or 3 re-breathings and shows intersubject variations of up to 1°C at the same expired volume.

The breath alcohol also rises rapidly at first and is still rising at the end of a full VC expiration and does not flatten out until after 2 or 3 re-breathings.

The smaller, undifferentiated dots show the alcohol concentration that would be expected if it depended solely on temperature, as suggested by Liljestrand and Linde (27). The points were obtained by calculation from the observed temperature and the 100% level, using a temperature coefficient of 6.3% per degree. It can be seen that the alcohol level lags behind the expected level and does not reach it until both curves flatten out after 2 or 3 re-breathings.

DISCUSSION OF THE HISTORICAL SURVEY

Our historical survey of breath alcohol analysis shows that there have been good reasons to doubt the validity of blood alcohol estimates obtained by breath analysis, and that, in the early years, its reliability was considerably overestimated. In view, however, of the very high blood alcohol levels (up to 150 mg/100 ml) that were tolerated in those days, no injustice is likely to have been caused by relying solely on breath analysis. Moreover, since the introduction of the Breathalyzer, the blood alcohol has usually been underestimated by 10-15% which has been a further precaution against injustice. Unfortunately, however, this argument has been, and still is being, used to ignore, or even deny (10), this constant error, with the result that there have been no previous systematic investigations of its origin. Similarly, the desire of the Courts for a simple 'yes' or 'no' answer has led to a reluctance to do repeated breath analysis, or both breath and blood alcohol analyses in forensic cases. Thus, the non-reproducibility of breath analysis and its relatively poor agreement with blood analysis have not been apparent.

The curious Haggard and Greenberg, (16, 17) and Payne *et al.* (30) episodes have also contributed to reasonable doubts about the validity of breath analysis, though recent studies, including our own, with more reliable instruments and more careful observers have amply confirmed that the determination of the BAC from breath is possible with a precision and accuracy which, though not quite as good as obtained with direct blood analysis in the laboratory, are quite adequate for practical purposes.

DISCUSSION OF THE EXPERIMENTAL STUDIES

In vitro Studies

Our fresh determination of the air/water partition ratio for alcohol using a new technique agrees well with the results of previous workers. As it depends only on analysis of the liquid phase, it makes no assumptions about the reliability of gas analysis and so can be validly used to check the reliability of our air-alcohol standards.

Our redetermination of the air/blood ratio *in vitro* at various temperatures is only the fourth that has ever been made. Of these, that of Liljestrand and Linde (27) was too hampered by technical difficulties to be of much evidential value. In particular, they obtained a ratio of 1 : 2000 at 31° which is about 20% too high for that temperature. The common habit (24) of quoting their results as supporting this ratio is not therefore justifiable.

Haggard and Greenberg's results (16, 17) must, of course, be disregarded, but our excellent agreement with Harger's figures (21), allowing for the 'salting out' effect of sodium fluoride, makes us feel that further work in this field is probably unnecessary.

Our observation of the difference in the *in vitro* ratio between men and women shows that variations in haematocrit, as suggested by Payne *et al,* (31) must contribute to variations in the breath blood ratio *in vivo* because the alcohol in the breath is derived from blood by equilibration while blood analysis is normally on a weight/volume or volume/volume basis. Hitherto the lack of precise analytical methods and the other causes of variation in the ratio have made haematocrit effects relatively unimportant (39), but now that breath analysis is becoming much more precise it must be pointed out that, where there is a discrepancy between breath and blood from this cause, the breath estimate is to be preferred as it depends on the partial pressure of alcohol in the tissues which presumably controls its effect on the brain (39). Conversely, this source of error could be eliminated if breath analysis were carried out by direct head space chromatography on whole blood. However, apart from technical problems, this would have to involve a change in legislation since all standards are at present based on weight/volume or volume/volume analysis.

Breath/Blood Correlation Study

As already noted, our observation that the best estimate of the breath/blood ratio is 1 : 2300 and not 1 : 2100 is now commonplace, as is our observation that the variability of the ratio is substantially greater than can be accounted for by the analytical errors of breath and blood analysis.

Our figure of 0.5 mg for the SD of air-alcohol analysis may seem low, but, considering the much more reliable standard and much more precise analyser that we used, it is not so much lower than the figure of 1.3 mg found by Britt and Borkenstein using a Breathalyzer and "Alcoholic Breath Simulator" in 1965 (6).

The low and variable SD for repeated breaths is interesting and confirms the observation of Enticknap and Wright (11) that the breath/blood ratio can sometimes change without any change in breath concentration, and that individual variations in the stability of the breath concentration occur.

The Alcohol Expirogram

Our demonstration of the changes that occur in the alcohol level during expiration and their relation to volume and temperature (Figure 4) seem to us to be the most valuable result of our work. It is easy to see that the alcohol level in any single breath is lower than predicted by the accepted theory, and why, with the Breathalyzer, where the subject is free to discard a volume varying from a few hundred ml to several litres, the results should be so variable. The Kitagawa-Wright, with its fixed discard volume of 500 ml, is little better because the alcohol level at this volume is still rising sharply and variations of up to 10% for different subjects are still occurring. It is not until after two or three rebreathings that the variation falls to within ± 3% of the mean level and the level flattens out.

Theory of the Alcohol Expirogram

The classical theory of Lindjestrand and Linde (27) postulated that alcohol in breath behaved very like CO_2, so that it was only necessary to obtain an alveolar air sample to be able to determine the alcohol concentration in the blood, provided that allowance was made for re-equilibration at a lower temperature during expiration. Harger's observations (21) that the average temperature of expired air was 34°, which gave an *in vitro* ratio of 1 : 2100, and that the *in vivo* ratio was also about 1 : 2100, led to the adoption of this ratio as the correct one. In fact, as Figure 4 shows, the alcohol level does not reach that predicted for the breath temperature until after two or three rebreathings. This cannot be attributed to a failure of temperature equilibration, however, since the breath from the alveoli is at a higher temperature and a failure of temperature equilibration would lead to a *higher* and not a *lower* breath alcohol level than expected.

We have therefore to look for a mechanism which causes alcohol to be lost from the breath during expiration, to a variable extent, decreasing with volume expired and only reaching its proper level after rebreathing. We believe that this mechanism lies, as suggested by Forster (12), in the respiratory dead space. This consists of the conducting airways of the respiratory tract and extends from the lips to the respiratory bronchioles. It is called 'dead' because gas exchange through its surface between blood and air is very slow compared with that in the alveoli. The concept of "alveolar air" therefore is that it is the fraction of the breath that emerges after washing out the 'anatomical' dead space, which has a volume of about 200 ml. Haldane and Priestley (18) showed that the CO_2 level reached a plateau after 500 ml had been discarded, at the end of a normal expiration, *i.e.* during quiet breathing. More recent studies, using a mass spectrometer (10), have shown that up to 65% of the vital capacity may need to be discarded before the CO_2 level becomes stable, if the expiration follows a deep inspiration.

Figure 5 shows a typical CO_2 expirogram obtained by mass spectrometry and it will be seen that, at first glance, it closely resembles the alcohol expirogram. In fact, however, there are two important differences. The CO_2 level starts at zero, whereas the alcohol level, even at a 100 ml expired volume is over 90% of the predicted level for the breath temperature, and the alcohol level, as already noted, rises continually throughout one single breath.

These differences can be shown to be due to the great differences in the solubility of CO_2 and alcohol in water and the much higher concentration of CO_2 in the blood and breath. The partition ratio for CO_2 is 1 : 1.5 at 34° (33) which is nearly 1,400 times as high as that of alcohol, and its concentration in breath is 200 times as high as that of alcohol at a blood level of 100 mg/100 ml. In addition, CO_2 is carried in the blood in the red cells, so that virtually no interchange takes place with plasma or other body fluids. Alcohol, on the other hand, diffuses freely through all body fluids including the layer of mucus covering the surface of the dead space. This layer is about 5 microns thick and covers a surface of about 6000 cm^2 (35) so it has a volume of about 3 cm^3. This can absorb about half the alcohol from six litres of breath while it can only absorb the CO_2 from about 20 ml.

It therefore seems that the loss of alcohol from breath during expiration can be explained quite simply as follows. In the fully equilibrated state the dead space mucus will contain alcohol at the same partial pressure as in the rest of the body but, during inspiration, air with no alcohol in it passes over the mucus and must extract alcohol from it. If this is not replaced immediately from the blood it will be replaced from the expired air whose alcohol level will be thereby lowered. This is a simple and attractive hypothesis, but two conditions must be satisfied before it can be accepted. The first is that the alcohol lost to the mucus cannot be completely replaced from the blood stream between inspiration and expiration. The blood supply to the mucosa is rela-

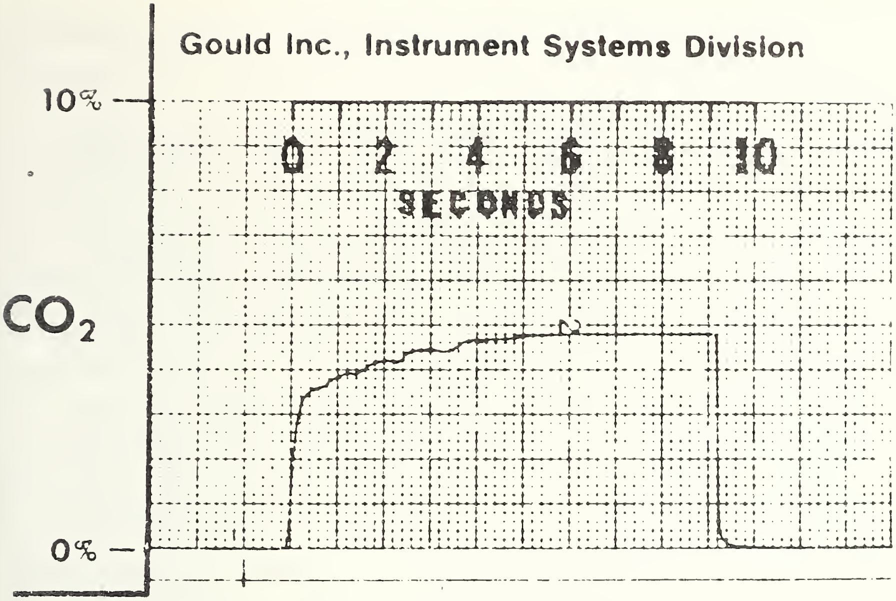


Figure 5 *CO_2 expirogram by mass spectrometry. Reproduced with permission from K. Dubowski, (10).*

tively good, though in no way comparable to that of the alveoli, the blood being about 50 microns from the surface instead of about 1 micron as in the alveoli, and with an enormously smaller surface/volume ratio. Only very rough estimates of the time taken for complete replacement to occur can be made by theoretical calculations so we carried out two simple experiments. The first showed that, after rebreathing, it took three breaths of fresh air to restore the breath alcohol to its normal level. The second showed that, if a subject held his breath with the mouth closed for thirty seconds after a deep inspiration, the alcohol level in an ordinary expired sample reached the rebreathed air level. From these two experiments it seems that it takes much longer than the normal interval between inspiration and expiration for the alcohol abstracted from the mucus during inspiration to be replaced. It also suggests that the effect of rebreathing is, in part, to allow time for the mucosal alcohol to be replaced from the blood as well as directly from the breath. The relative importance of these two factors could be determined by varying the duration and frequency of rebreathing, but we have not yet investigated this point.

The second requirement is that alcohol must evaporate from the mucosa more rapidly than water so that its concentration in the mucus will fall. It can be shown by simple calculation from the partition ratio and the saturation level of water vapour in air that the alcohol/water ratio in air at body temperature is about eight times that in water, so there is no doubt on this point.

In the light of this theory it is easy to see the reason for the difference between the CO_2 and alcohol expirograms. CO_2 starts from zero because air in the anatomical dead space has no contact with red cells and so acquires no CO_2. Alcohol on the other hand does not, because almost complete equilibration with the mucosa of the dead space takes place very rapidly. It must be remembered that most of the surface of the dead space is in the smaller bronchi where the temperature is nearly 37° and the surface/volume ratio is relatively high.

CO_2 will only reach a plateau after a 500 ml discard, however, if the expiration, expiration follows on the end of a normal tidal expiration, as in Haldane and Priestley's original description (18). When, as is usually the case with breath sampling for alcohol, a deep breath is taken first, many more alveoli are opened up and some of these, due to ventilation/perfusion defects, may not have become fully equilibrated for CO_2. The result is an apparent increase in the dead space, known as the 'physiological' dead space so that, as noted earlier, several litres may need to be discarded before a stable CO_2 level is obtained. This effect does not operate with alcohol because it equilibrates instantaneously in the alveoli and, as we have seen, very rapidly with any tissue fluid. Even a so-called 'unperfused' alveolus must have some tissue fluid supply with which alcohol can equilibrate. The 'physiological' dead space for alcohol is therefore actually in the anatomical dead space in the form of the mucus layer and it is evident that it carries a chronic alcohol debt that can only be fully repaid if inspiration of fresh air is stopped either by holding the breath or by rebreathing.

If we accept the dead space theory as a more or less complete explanation of the excretion of alcohol in breath the air/blood ratio *in vitro* can be seen to be of no importance, except as mentioned above, because the final determination of the breath /blood ratio *in vivo* takes place in the dead space. The observed breath/blood ratio *in vivo* must therefore be governed almost entirely by the condition of the dead space mucus. Such factors as the ascularity of the mucosa, the thickness of the mucus, the body temperature, patterns of breathing, and the temperature and humidity of the inspired air are what must be taken into account when trying to explain the variations in breath blood ratio which are observed. If anything is to be done, apart from instrumental improvements, to improve the reliability of breath testing, this is the field in which research is required. Such research is now relatively easy to carry out, especially with the aid of a mass spectrometer, because it does not require blood analysis which can be replaced by an analysis of rebreathed air.

REFERENCES

1. Begg, T. B., Hill, I. D., and Nickolls, L. C., Breathalyzer and Kitagawa-Wright Methods of measuring Breath Alcohol. *British Medical Journal* i, 9 (1964).
2. Bogen, E., Drunkenness, Quantitative Study of Acute Alcohol Intoxication. *Journal American Medical Association* 89, 1508 (1927).
3. Borkenstein, R. F. and Smith, H. W. The Breathalyzer and its Application. *Medicine, Science and the Law* 1, 13 (1961).
4. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B. and Zylman, R., *The Role of the Drinking Driver in Traffic Accidents.* Indiana University, Bloomington, Indiana, U.S. 1964.
5. *British Medical Journal:* Editorial: Distribution of Alcohol in the Body, i, 184 (1966).
6. Britt, B. J. and Borkenstein, R. F., Reproducibility of Breathalyzer using an Alcoholic Breath Simulator: In, *Alcohol and Traffic Safety: Proceedings of the Fourth International Conference on Alcohol and Traffic Safety,* Bloomington, Indiana University, 1966, p. 140.
7. Cox, L. A., Almeida, A. P., Robinson, J. S. and Horsley, J. K., An Electronic Respirometer. *British Journal of Anaesthesia* 46, 302 (1974).
8. Curry, A. S., Walker, G. W. and Simpson, G. S., Determination of Ethanol in Blood by Gas Chromatography, *Analyst* 91, 742 (1966).
9. Dubowski, K. M., Measurement of Ethyl Alcohol in Breath. In *Laboratory Diagnosis of Diseases caused by Toxic Agents.* F. W. Sunderman and F. W. Sunderman Jr. (Eds.). W. H. Green, St. Louis, Mo. 1970. Chapter 31.
10. Dubowski, K. M., Biological Aspects of Breath Analysis, *Clinical Chemistry* 20, 294 (1974).
11. Enticknap, J. B. and Wright, B. M., In-Vivo Determination of the Breath-blood Ratio. In,

Alcohol and Traffic Safety: Proceedings of the Fourth International Conference on Alcohol and Traffic Safety, Bloomington, Indiana University, 1966, p. 161.

12. Forster, R. E., Breathing Tests for Alcohol, *Journal American Medical Association* **190**, 197 (1964).

13. Franklin, S., A Comparisons of Whole Blood: Breath Correlations with Blood Plasma: Breath Correlations for Alcohol Concentration. *Proceedings of the Fifth International Conference on Alcohol and Traffic Safety.* H. F. Schutz Verlag, Freiburg, Germany, 1969, p. 99.

14. Fox, B. H., Hallett, R. A., Makowski, W., Schnall, A. M. and Pelch, A., Refined Comparison of Blood- and Breath-Alcohol Measures and variability of Breaths around Trend of Decline. In, *Alcohol and Traffic Safety: Proceedings of the Fourth International Conference on Alcohol and Traffic Safety.* Bloomington, Indiana University, 1966, p. 128.

15. Greenberg, H. W. and Keator, F. W., Portable Automatic Apparatus for Indirect Determination of the Concentration of Alcohol in the Blood, *Quarterly Journal of Studies on Alcohol* **2**, 57 (1941).

16. Haggard, H. W. and Greenberg, L. A., Studies on Absorption, Distribution and Elimination of Ethyl Alcohol. II. The Excretion of Alcohol in Urine and Expired Air; and the Distribution of Alcohol between Air and Water, Blood and Urine. *Journal Pharmacology and Experimental Therapeutics* **52**, 150 (1934).

17. Haggard, H. W., Greenberg, L. A., Miller, D. P. and Carroll, R. P., The Alcohol of the Lung Air as an Index of Alcohol in the Blood. *Journal of Laboratory and Clinical Medicine* **26**, 1527 (1941).

18. Haldane, J. S. and Priestly J. G., The Regulation of Lung Ventilation. *Journal of Physiology* **32**, 225 (1905).

19. Harger, R. N., Science News. *Science* **73**, 10 (1931).

20. Harger, R. N., Lamb, E. G. and Hulpieu, H. R., Rapid Chemical Test for Intoxication Employing Breath. *Journal American Medical Association* **110**, 779 (1938).

21. Harger, R. N., Forney, R. B. and Barnes, H. B., Estimation of the Level of Blood Alcohol from Analysis of Breath. *Journal of Laboratory and Clinical Medicine* **36**, 306 (1950).

22. Harger, R. N., Raney, B. B., Bridwell, E. G. and Mitchell, M. F.; The Partition Ratio of *Alcohol between Air and Water, Urine and Blood; Estimation and Identification of* Alcohol in these Liquids from Analysis of Air Equilibrated with them. *Journal of Biological Chemistry* **183**, 197 (1950).

23. Harger, R. N., Forney, R. B. and Baker, R. S., Estimation of the Level of Blood Alcohol from Analysis of Breath. II. Use of rebreathed air. *Quarterly Journal of Studies on Alcohol* **17**, 1 (1956).

24. Harger, R. N. and Forney, R. B., Aliphatic Alcohols. In *Progress in Chemical Toxicology,* **3**, Academic Press Inc., New York, 1967.

25. Kitagawa, T., Detector Tubes for Analysis of Alcohol in Breath. In, *Alcohol and Road Traffic. Proceedings of the Third International Conference on Alcohol and Road Traffic.* British Medical Association, London, 1962, p. 246.

26. Kitagawa, T. and Wright, B. M., A quantitative Detector-tube Method for Breath-alcohol Estimation. *British Medical Journal* **ii**, 65 (1962).

27. Liljestrand, C. and Linde, P., Ueber die Ausscheidung des Alkohols mit der Expirationsluft. *Skandinavischen Archiv f. Physiologie* **60**, 273 (1930).

28. Mason, M. F. and Dubowski, K. M., Alcohol, Traffic and Chemical Testing in the United States: A Resume and Some Remaining Problems. *Clinical Chemistry* **20**, 126 (1974).

29. Noordzij, P. C., Comparison of Instruments for Determining Blood Alcohol Concentration. *Proceedings of the Fifth International Conference on Alcohol and Traffic Safety.* H. F. Schutz Verlag, Freiburg, Germany, 1969, p. 33.

30. Payne, J. P., Hill, D. W. and King, N. W., Observations on the Distribution of Alcohol in Blood, Breath and Urine. *British Medical Journal* **i**, 196 (1966).

31. Payne, J. P., Hill, D. W. and Wood, D.G.L., Distribution of Ethanol between Plasma and Erythrocytes in Whole Blood. *Nature* **218**, 1263 (1968).

32. Penton, J. R. and Forrester, M. R., A Gas Chromatographic Breath Analysis System with Provisions for Storage and Delayed Analysis of Samples. *Proceedings of the Fifth International Conference on Alcohol and Traffic Safety.* H. F. Schutz Verlag, Freiburg, Germany, 1969, p. 79.

33. Power, G. G. and Stegall, H., Solubility of Gases in Human Red Cell Ghosts. *Journal of Applied Physiology* **29**, 145 (1970).

34. Smith, J. C., The Avoidance of Biologic Variables in Breath Tests for Alcohol in Blood. *American Journal of Clinical Pathology* **32**, 34 (1959).

35. Weibel, E. R., *Morphometry of Human Lungs.* Springer-Verlag, Berlin, 1963.

36. Wright, B. M., A Respiratory Anemometer. *Journal of Physiology* **127**, 25P (1955).

37. Wright, B. M., Breath Alcohol Analysis. In, *Alcohol and Road Traffic. Proceedings of the Third International Conference on Alcohol and Road Traffic,* British Medical Association, London, 1962, p. 251.

38. Wright, B. M., Breath Alcohol Analysis. *British Medical Journal* **i**, 182 (1964).

39. Wright, B. M., Distribution of Ethanol between Plasms and Erythrocytes in Whole Blood. *Nature* **218**, 1263 (1968).

Errors in Current Alcohol Breath Analysis

J. Levett[1] and L. Karras

On September 29, 1969, Section 11-501 of the Illinois Vehicle Code (Suspension of License – Implied Consent) was approved in an effort to curb highway deaths due to consumption of alcoholic beverages by the driver. Section 11.501-1 states that any person operating a vehicle, who is lawfully arrested on the roads of Illinois, must submit to a breath test if he/she is suspected of driving under the influence of alcohol. The breath test will examine a breath sample for alcohol content, which is then expressed in terms of a bood alcohol concentration (BAC). A BAC of 100 mg of ethanol/100 ml of blood or higher is considered proof of driving under the influence in the State of Illinois.

The "Breathalyzer, model 1000", manufactured by Smith and Wesson is the automated breath analyzing instrument most commonly used in Illinois. Tests were conducted using the Model 1000 Breathalyzer to determine how closely the BAC established via a breath test correlated with the BAC determined via a blood sample. The Breathalyzer, as stated by the manufacturer (4), needs a minimum of 452.5 ml of lung air from a subject to advance the instrument to the analysis stage where the breath sample is automatically analyzed for alcohol content. In the Breathalyzer only the last 52.5 ml of expired air given to the instrument is used for analysis. Thus, if the minimum amount of air, 452.5 ml, is given to the Breathalyzer only the last 52.5 ml of air will be analyzed for alcohol content. Likewise, if a subject expired 2000 ml of air into the instrument it would still be only the last 52.5 ml of air that the Breathalyzer analyzed. In a legal sense, expiring only 452.5 ml of air into the Breathalyzer would be acceptable. The problem is that if a minimum amount of air is given to the Breathalyzer, it will not give an accurate reading indicative of the actual BAC of the person being tested.

Tests were conducted which showed that the Breathalyzer could give readings much lower than the expected readings. This problem was brought to the attention of manufacturers, and the instrument was modified to ensure obtaining alveolar air for analysis. The same tests as previously used to determine Breathalyzer accuracy were then repeated on the modified Breathalyzer to determine the improved correlation between the breath sample and blood sample.

---

[1] Dept. of Biomedical Engineering, Rush-Presbyterian-St. Luke's Medical Centre, Chicago, Illinois 60612, U.S.A.

PROCEDURES AND METHODS

The Breathalyzers used in these experiments were examined for accuracy by the Illinois Department of Public Health and each examination showed that the instrument was properly calibrated and usable under the criteria given in the Implied Consent legislation.

The experiments involved two phases. The first phase used the Breathalyzer as now used in the field, while the second used an instrument with modified intake controls to guarantee a minimum airflow rate for a specified duration when a breath sample was taken using the Breathalyzer. Twenty-five subjects were used in each phase, and each phase consisted of about 15 sessions.

The Breathalyzer was tested before and after each session with a simulator of known value to insure that calibration was proper. In no case did the before-and-after simulator tests differ. All subjects were given one hour to drink an alcoholic beverage of their choice and they were allowed to drink whatever amount they felt they could handle, as long as their predicted BAC did not exceed 250 mg/100 ml. No eating or smoking was allowed during the experiment. A waiting period of one hour followed the drinking hour before automated breath testing began. This hour was necessary to eliminate any differences in the breath and blood-alcohol tests that may have arisen due to the dynamic characteristics of the absorption phase where the breath alcohol level is higher than the venous blood alcohol level (2, 3). After the one-hour wait, subjects were instructed to blow into the Breathalyzer and were told to stop blowing one second after an obvious click was heard coming from the Breathalyzer. This click was due to an electromechanical switch in a cylinder tripped by a piston when 452.5 ml of air had entered the intakes of the Breathalyzer. This breath sample procedure usually lasted about three seconds and met the legal minimum breath sample requirement since it proved sufficient to activate the instrument. This was then defined as the minimum breath sample. The subject's arm was then cleaned with benzykonium chloride and a venous blood sample was taken. After the Breathalyzer analyzed the breath sample the Breathalyzer's ampoule containing a chemical reagent and the saliva trap were changed. The instrument was then immediately recycled for another breath test. The subject was instructed to blow into the Breathalyzer until no more air could be forced out of the lungs. This was the maximum breath sample. The order of obtaining minimum breath tests was reversed in a random fashion.

A second venous blood sample was taken from 10 of the 25 subjects. The blood was drawn into a vacutainer containing oxalate, an anti-coagulant, and refrigerated until it could be analyzed. The blood samples were analyzed within 36 hours by a biochemistry laboratory that has facilities certified by the Department of Public Health for such an analysis.

The Breathalyzer was modified in an effort to ensure the sampling of only alveolar air reflecting the actual BAC. Originally, the Breathalyzer used in Illinois had an input breath tube which fed directly into a cylindrical chamber with a volume of 52.5 ml. This chamber was in series with another cylindrical chamber of equal size and had a portioning valve to ensure that the subject blows at least 452.5 ml of air to trigger an electromechanical switch. Activation of this switch advanced the Breathalyzer to the analysis stage when a subject had completed his expiratory effort. The contents of the first chamber were then analyzed to determine the BAC of the subject tested (4).

The modification of the Breathalyzer consisted of disabling the electromechanical switch in the second chamber and installing a rated-airflow valve and a timing circuit. The rated airflow valve is inserted in such a way that air blown in by the subject must pass through the valve first before entering the first chamber. When a subject delivers a specified minimum airflow rate (six liters per minute) a switch opens and a timing circuit starts. The timing circuit is set for a maximum of six seconds. Therefore, the Breathalyzer advances to the analysis stage only when the minimum airflow rate (six liters per minute) has been maintained for six seconds, thus a minimum breath sample has a volume of 600 ml. In summary, minimum and maximum breath sample readings taken six minutes apart were compared to corresponding blood sample readings before and after the Breathalyzer was modified.

RESULTS AND DISCUSSION

During each phase of testing, that is, before and after modifications were made on the Breathalyzer, 10 of the subjects had a blood sample taken immediately after each minimum and maximum breath test was completed. Our findings show that two blood samples taken at a maximum time separation of 10 minutes yielded an average difference in BACs of 5 mg/100 ml. Therefore, it was not necessary to take a blood sample after each maximum and minimum breath test since variations between the blood samples was insignificant. The remaining 15 subjects had only one blood sample taken in the time period (six minutes) between minimum and maximum breath tests.

Figure 1 shows the variation in minimum and maximum breath tests at the corresponding BAC determined via blood samples before the modification of the Breathalyzer. Differences in minimum and maximum breath tests were as great as 70 mg/100 ml. Table I indicates that the Breathalyzer was, on the average, 49% below the actual BAC on minimum breath tests and 22% below the actual BAC on maximum breath tests for the BAC ranges shown in Table I. This also is shown in Figure 2 by the slope of the lines as determined by the average error in the breath test as a function of the actual BAC. Minimum breath tests gave errors ranging from 28% to 64% below the actual breath test, whereas maximum breath tests had a range of error from 1% to 37% below the actual BAC.

TABLE I *Percentage Difference between Breath Test Results and actual BAC*

BAC Range Via Blood Samples mg/100ml	Breath Tests Before Modifications				Breath Tests After Modifications			
	Range of Percentages Below Actual BAC		Average Percentage Below Actual BAC		Range of Percentage Below Actual BAC		Average Percentage Below Actual BAC	
	Minimum Breath	Maximum Breath	Minimum Breath	Maximum Breath	Minimum Breath	Maximum Breath	Minimum Breath	Maximum Breath
1 to 100	39-64	2-33	51	23	14-52	2-37	34	23
101 to 150	28-63	1-35	45	18	17-50	6-36	33	21
151 to 200	35-62	17-28	50	20	34-39	14-29	36	22
201 to 300	43-57	18-37	48	27	25-44	8-31	33	22
Average Percentage Below Actual BAC of the Four BAC Ranges			49	22			34	22

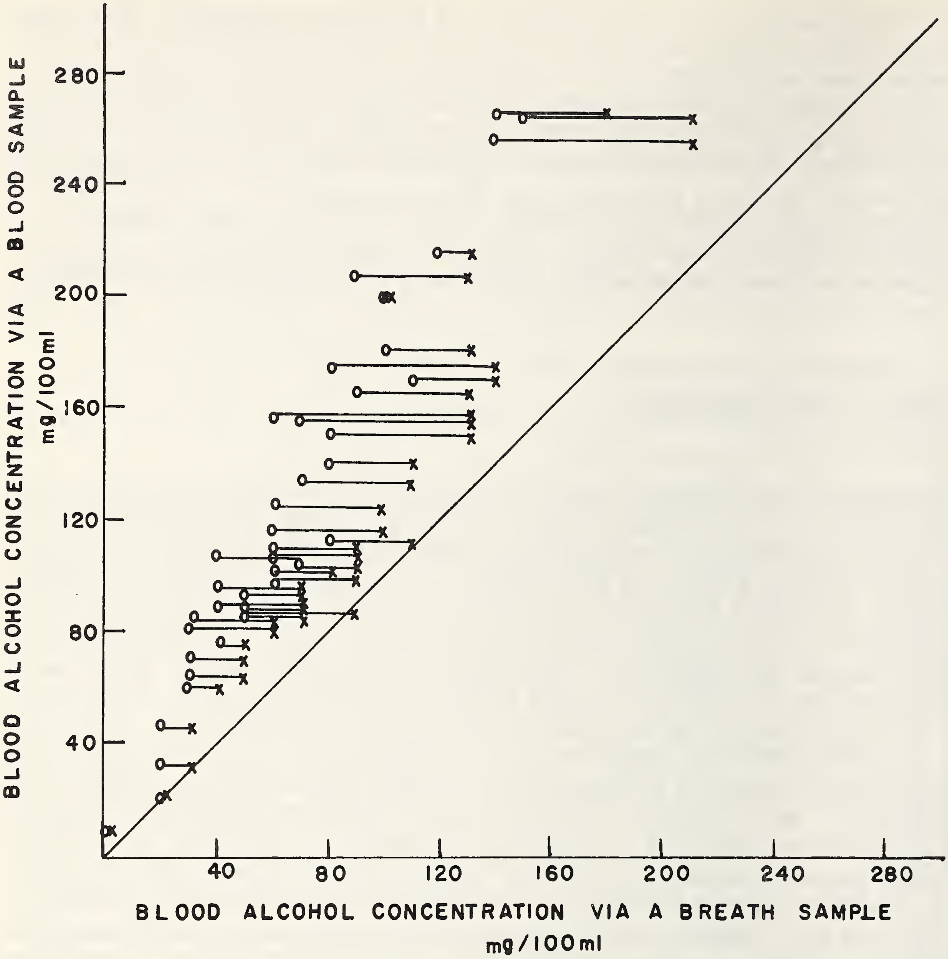


Figure 1 *BAC via minimum and maximum breath samples given to a Breathalyzer versus the BAC determined via a blood sample. Breathalyzer before modifications. Breath samples were taken six minutes apart. x = maximum, o = minimum.*

After the intake controls of the Breathalyzer had been modified, differences in minimum and maximum breath tests ranged from 0 mg/100 ml to 40 mg/100 ml. This is a decrease of 30 mg/100 ml in the largest disparity between the minimum and maximum breath tests. After modifications the Breathalyzer was about 34% below the actual BAC for minimum breath tests and 22% below the actual BAC for maximum breath tests for the BAC ranges shown in Table I. This is a decrease of 15% in error for the minimum breath test after the Breathalyzer was modified. The per cent of error below the actual BAC remained the same for maximum breath tests as was expected. Minimum breath tests ranged 14-52% below the actual BAC, while the maximum breath tests were 2-37% below the actual BAC. Figure 2 shows that after modifications there is a decrease in the slope of the minimum breath test error while the slope of the maximum breath test error is essentially the same as before modifications as shown in Figure 2.

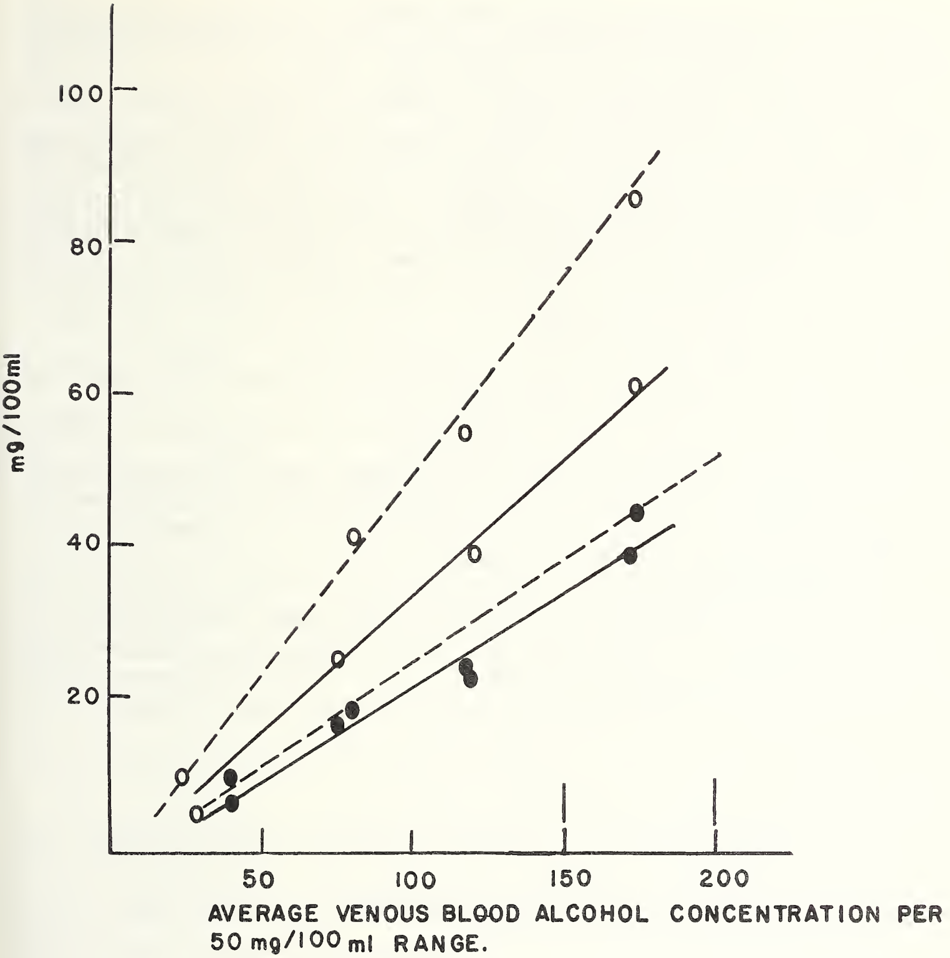


Figure 2 *Breathalyzer error versus BAC via blood samples per 50 mg/100 ml range before and after modifications.*

— — — — — *Breathalizer before modifications.*

———————— *Breathalizer after modifications.*

$$\text{O} = \text{ERROR}_1 \ \text{mg/100ml} = \frac{\Sigma(\text{BAC}-\text{B}_{\text{min}})}{\text{NO. OF B}_{\text{min}}\text{ SAMPLES IN A 50 mg/100ml RANGE}}$$

$$\bullet = \text{ERROR}_2 \ \text{mg/100ml} = \frac{\Sigma(\text{BAC}-\text{B}_{\text{max}})}{\text{NO. OF B}_{\text{max}}\text{ SAMPLES IN A 50 mg/100ML RANGE}}$$

The above results show that to obtain a breath sample that reflects the BAC as accurately as possible the minimum breath sample must be more than the 452 ml now required by Breathalyzers used in Illinois. Using a minimum breath sample on the current Breathalyzer in Illinois one could expect a 49% error in determining the actual BAC. Although the first 452 ml of expired air usually assures that dead-space air has been removed and only alveolar air remains, it is questionable whether the first 452 ml of expelled air has reached equilibrium with the blood to contain an alcohol concentration indicative of the actual BAC. The above results confirm that equilibrium had not been reached with a minimum breath sample of 452 ml.

Modification of the intake controls as outlined previously ensured a 600 ml minimum breath sample. This reduced the expected error from 49% to 34% when analyzing a minimum breath sample. This indicates that the Breathalyzer needs to have the breath-intake controls adequately modified if it is to make an accurate correlation to the actual blood alcohol levels. It is suggested that the intake controls be modified such that a minimum expiratory effort would have a volume of 800 ml. Although unproven, the minimum 800 ml of expired air would ensure obtaining a Breathalyzer reading of BAC close to that obtained from a maximum expiratory effort which is normally 10-20% below the actual BAC.

Caution should be taken in modifying the intake controls such that the flow rate is not too high. Currently, the modified Breathalyzer has a flow rate of six liters per minute and about one-third of the subjects used in these experiments complained about the difficulty of blowing into the Breathalyzer. Several tests could not be completed because a few subjects could not sustain this flow rate for six seconds. A flow rate of five liters per minute for 9.5 seconds would ensure obtaining with ease about 800 ml of air as a minimum breath sample.

It should be emphasized that a determined effort to obtain a maximum breath ensures close correlation with the actual BAC (10-20% below the BAC). Therefore, under a strict protocol to obtain a maximum breath sample, the unmodified Breathalyzer is a reasonably accurate and effective instrument for law enforcement, since it measures accurately the alcohol content of whatever breath sample it obtains.

REFERENCES

1. Guyton, Arthur C., Pulmonary Ventilation, in *Textbook of Medical Physiology*, W. B. Saunders, Philadelphia, 1971.
2. Harger, R. N, Forney, R. B., and Baker, R. S., Estimation of the Level of Blood Alcohol from Analysis of Breath, *Quarterly Journal of Studies on Alcohol* 17, 1-18 (1956).
3. Levett, J., and Karras, L., Implied Consent and Scientific Instrumentation to Make it Work, *Lex et Scientia* 9, 85 (1973).
4. Smith and Wesson Electronics, *Breathalyzer Model 1000 Operator's Manual*, Eatontown, New Jersey, 1972.

The Range of Concentrations of Free Acetone in the Plasma and Breath of Diabetics and Some Observations on its Plasma/Breath Ratio

Morton F. Mason[1], and Don Hutson[2]

Until comparatively recent times, little certain quantitative information has been available concerning the concentration of free acetone in the blood, plasma or serum of normal subjects or patients with ketosis. This is in part due to the very small amounts of acetone normally present and to the spurious formation of acetone by decarboxylation of acetoacetic acid in various volumetric and photometric methodologies (6).

Breath-acetone concentrations were first reliably established in 1952 by a procedure employing mass spectrometry devised by Henderson, Karger and Wrenshall (5). The range of quantities found has since been confirmed by other techniques, e.g. measurement of infrared absorbance at 8.25 microns using long light-path cells (10) and various gas chromatographic methods (1, 2, 8, 9, 11, 12, 13). There are few data on the plasma (or serum)/breath ratio for acetone. The value most frequently quoted – 330 – appears to be based upon measurements by Widmark (14, 15) and Haggard, Greenberg and Turner (3) dealing with breath and whole blood at body temperature.

The purpose of the present study is to confirm the range of concentrations of acetone in the plasma (or serum) of normal subjects and in subjects with ketosis and to obtain values of the plasma-breath ratio of acetone at various temperatures, including 34.5°C. Such data, eventually, should permit estimation of the degree and frequency of concentrations of acetone in the breath of ambulatory subjects that might cause significantly false high values to be obtained for ethanol by use of breath-testing instruments employing oxidative reactions or infrared absorbance rather than gas chromatography.

METHOD

Acetone concentrations in plasma (and breath in some instances) were determined by use of the Diet Monitor, a gas chromatograph (GC) modified for use in diet control by Cal-Detect, Inc. (7). It is designed so that exhaled breath delivered into it has its temperature increased after which a 2ml volume is measured and passed into a GC column (Carbowax on Chromosorb P). A digital readout of a peak height is provided

---

[1] Department of Pathology and Institute of Forensic Sciences, University of Texas Southwestern Medical School, Dallas, Texas, U.S.A.

[2] Cal-Detect, Inc., 101 Nevin Avenue, Richmond, California, U.S.A.

during an isolated portion of the subsequent time sequence which includes the retention time of acetone. Alternatively, a smaller sample (greater than 15 ml) may be injected into an auxiliary port of which 2 ml is taken for analysis. In any event, the relation of digital reading to the amount of acetone in the sample must be established by analysis of some type of reference specimen, e.g. argon or some other gas containing a known percentage of acetone. A more direct procedure which we used consisted of introducing 3.0 μl of aqueous reference acetone solution into a slightly warmed 100 ml dry glass syringe. After adjustment of the volume to 100 ml, mixing was achieved by several passes into a second dry glass syringe, essentially as described by Harger and Turrell (4), followed by injection of a portion of the sample now at 25°C, into the auxiliary port of the instrument.

The arrangement employed is shown in Figure 1. Several readings for each of the reference solutions were obtained.

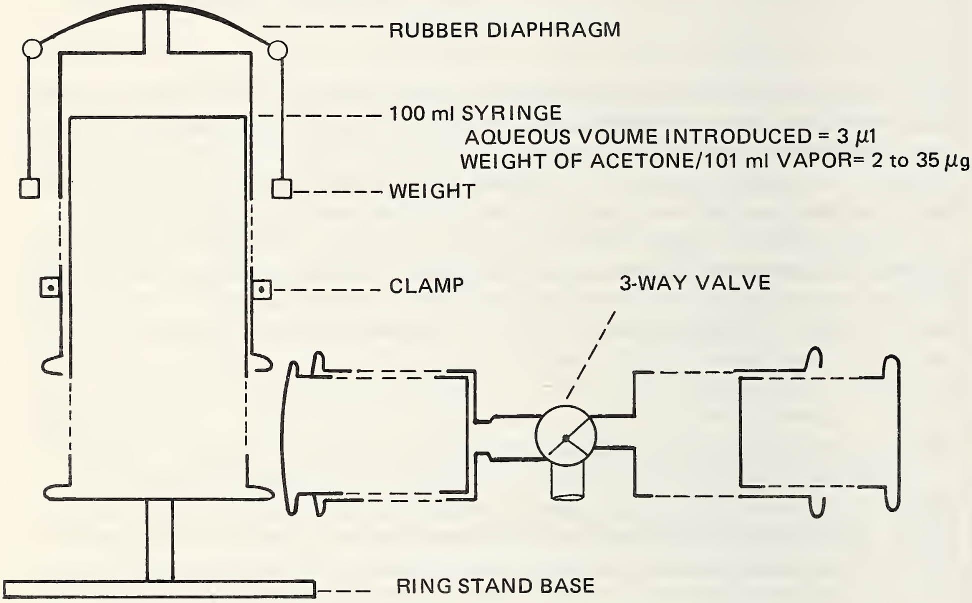

RUBBER DIAPHRAGM
100 ml SYRINGE
AQUEOUS VOUME INTRODUCED = 3 μ1
WEIGHT OF ACETONE/101 ml VAPOR= 2 to 35 μg
WEIGHT
CLAMP
3-WAY VALVE
RING STAND BASE

Figure 1 *Device for preparing reference acetone vapor. The base of the Ringstand Acts as a stop at the 100 ml Mark.*

Plasma (or serum) acetone determinations were made by transferring 1 to 5 ml of plasma or serum into a 50 ml plastic disposable syringe. After adjustment of the space to a volume of 40 - 60 ml the tip was closed with a plug made from Tygon tubing. After shaking for about three minutes, the syringe was placed in a water bath, usually at 34.5°C, with occasional release of pressure so that headspace equilibrium was obtained. Most of the headspace was then injected directly from the syringe into the auxiliary port of the Diet Monitor with the sample being taken from the terminal portion. The digital reading was recorded. Reference plasma (or serum) specimens containing known amounts of added acetone were similarly analyzed. The digital readings (corrected for any blank) were used to calculate the concentrations of acetone in vapors from 'unknowns' and the free acetone present in the plasmas or sera. The plasma/breath ratio was calculated from the values for acetone in the reference plasmas in their headspace vapors for the temperature chosen.

Blood was drawn into 5 ml Vacutainer tubes from three groups of subjects. The *first* comprised subjects free from known metabolic disease having blood sugar concentrations within the normal range. The *second* consisted of ambulatory subjects reporting to the Diabetic Out-Patient Clinic of Parkland Memorial Hospital most of whom had considerably elevated blood sugars and a few having abnormal amounts of ketone in their urines. The *third* group were non-ambulatory hospitalized patients, having plasma sugar values in excess of 300 mg/100 ml. Most were in the fasting state.

A *fourth* group comprising subjects brought to the emergency room with severe acidosis, ketonuria, marked hyperglycemia and impending or frank exhibition of diabetic coma will be reported later.

It was found that dilute aqueous standards of acetone ranging from 0.1 to 10 g/liter were stable for at least two weeks at room temperature (25°C). Plasma or serum specimens stored in the refrigerator at +2 – 4°C were also similarly stable. Multiple (at least 3) headspace determinations could be made on a single 5 ml specimen of plasma at concentrations above 1.0 mg/100 ml without significant decline in the headspace vapor concentration.

The detection limit of the instrument is less than 0.1 μg/100 ml in the vapor sample analyzed. Any change in the digital reading per unit mass of acetone due to change in functioning of the column was checked by determining the reading obtained on a standard argon-acetone gas mixture contained in a small tank at 500 – 1000 psi or by analysis of the head-space of a reference plasma standard. The retention time of acetone was checked with a stopwatch each day. Any change requires recalibration of the digital reading.

Data bearing on precision of the headspace measurements are shown in Table I. The precision of measurement of the reference gas mixture is very much better. Calculation indicates that the average of duplicate or triplicate headspace measurements provides a sufficiently accurate estimate of the acetone for the present purposes.

TABLE I *Standard Deviation and Coefficient of Variation of Measurements Obtained by the Syringe Headspace Technique*

ACQUEOUS REFERENCE STANDARDS	S.D.	C.V.
15.76 mg/100 ml	0.25	1.6
7.88 mg/100 ml	0.14	1.9
3.94 mg/100 ml	0.036	0.99
2.36 mg/100 ml	0.06	2.47
BLOOD BANK PLASMA REFERENCE STANDARDS		
15.76 mg/100 ml (added acetone)	0.29	2.6
7.88 mg/100 ml (added acetone)	0.44	2.7
4.73 mg/100 ml (added acetone)	0.145	3.6
0.79 mg/100 ml (added acetone)	0.078	8.7

RESULTS

Plasmas from 50 subjects believed to be free from metabolic disease contained free acetone ranging from none detectable in three instances to 0.28 mg/100 ml in the case of one subject. Forty-six were in the range of a trace, 0.02 - 0.04 (digital reading), to 0.15 mg/100 ml with most of the values being less than 0.1 mg/100 ml. Subjects certain of being a few hours postprandial gave the lowest figures. A plasma acetone of 1.0 mg/100 ml would cause the appearance of about 3 μg of acetone in deep lung air at 34.5°C. These values are in agreement with the findings of several investigators (2, 5, 8-13).

The findings were further confirmed by a small series of breath tests on normal subjects using the Diet-Monitor and the results obtained essentially agreed with those found previously with this instrument by Hutson (7).

Table II shows the results of 55 determinations on ambulatory subjects from the Diabetic Out-Patient Clinic with their corresponding plasma sugars and, in most instances, the qualitative ketone test of their urines using the "Multistix" procedure[3]. These data for acetone are summarized in Table IV. The two patients having plasma acetone concentrations in excess of 5 mg/100 ml were quite ill and were brought to their clinic appointment by others.

TABLE II *Acetone and Plasma Sugar Concentrations in the Plasmas of Ambulatory Diabetic Subjects*

Subject's Chart Number	Fasting Plasma Sugar mg/100 ml[a]	Urine Ketone (qual.)	Plasma Acetone mg/100 ml	Subject's Chart Number	Fasting Plasma Sugar mg/100 ml[a]	Urine Ketone[b] (qual.)	Plasma Acetone mg/100 ml
182945	–	Neg	0.39	062478	249	Neg	0.10
153910	–	Neg	0.08	294342	379	Neg	0.38
024042	–	Neg	0.31	315281	126	Neg	0.15
104833	–	Neg	0.05	376754	185	Neg	0.80
–	–	Neg	Neg	135705	335	Neg	0.66
–	–	–	0.16	055421	188	Neg	0.11
412280	184	Neg	0.15	175759	320	Neg	0.37
273076	354	Neg	0.32	290495	500	Small amount	5.7
076006	193	Neg	0.08	354354	–	Neg	1.1
479423	–	Small amount	0.10	061739	263	Neg	0.31
429482	383	Neg	0.93	268172	130	Neg	0.09
228910	–	Neg	0.18	310236	174	Neg	0.12
321865	161	Small amount	0.19	198673	167	Neg	0.76
057180	425	–	0.26	040689	241	Neg	0.15
059266	437	Neg	2.1	056141	268	Neg	0.59
052644	185	Neg	0.29	035759	207	Neg	0.17
338106	140	Neg	0.17	172018	310	–	0.15
099289	250	Neg	0.50	254991	167	–	0.09
206944	384	Neg	0.26	120774	305	–	0.18
444006	207	Neg	0.10	233878	130	–	0.14
417284	149	Neg	0.15	445138	149	Neg	0.09
462431	173	Neg	0.11	157667	142	Neg	0.32
322771	369	Neg	0.21	286846	361	Neg	0.15
306109	294	Neg	0.25	308086	185	Neg	0.41
063198	320	Neg	0.19	091798	143	Neg	0.06
309679	312	Moderate amount	8.1	179917	203	Neg	0.23
015775	208	Neg	0.13	249638	250	Neg	0.21
403627	390	Neg	0.42				

[a] SMA 1260
[b] "Multistix" (Ames Division of Miles Laboratories, Elkhart, Indiana)

---

[3] Ames Division of Miles Laboratories, Elkhart, Indiana.

TABLE III *Plasma Acetone Concentrations of Hospitalized Subjects with Plasma Sugar Values in Excess of 300 mg/100 ml*

Subject's chart number	Plasma Sugar mg/100 ml[a]	Plasma Acetone mg/100 ml	Subject's chart number	Plasma Sugar mg/100 ml[a]	Plasma Acetone mg/100 ml
374792	334	0.15	01784	372	0.39
304884	312	0.67	351291	396	0.10
311698	304	1.2	455116	400	2.5
447502	355	0.07	305261	715	0.47
460925	312	0.48	192328	388	0.13
455116	388	0.43	482757	540	0.65
438740	352	0.26	483601	336 (1 hour)	0.13
455116	780	6.1	483601	386 (2 hours)	0.06
474935	396	0.55	483601	510 (3 hours)	0.05
311698	390	0.68	159949	362	1.0
379403	382	0.31	414063	374	0.09
394905	390	0.88	478930	350	0.20
141320	372	0.16			

[a] Technicon AutoAnalyzer (ferricyanide reagent)

TABLE IV *Distribution of Subjects over the Various Plasma Acetone Levels*

Mg/100 ml	0-.1	.11-.5	.51-1	1.01-2	2.01-5	⩾5
Ambulatory diabetics[a]	11	36	4	1	1	2
Hospitalized patients[b]	5	11	6	1	1	1

[a] N = 55

[b] with plasma sugar values in excess of 300 mg/100 ml; N = 25

Tables III and IV show the results obtained on a series of hospitalized patients whose plasma sugar concentrations in the fasting state were found to be in excess of 300 mg/100 ml. Most were diabetics already receiving treatment.

These data, which will be greatly expanded, indicate that it is unlikely that a diabetic driving a motor vehicle will be found to have a plasma acetone greater than 5 mg/100 ml. The significance of the data in respect to breath analysis relates to the value of the plasma/breath ratio for acetone.

Figure 2 shows the relationship between digital reading and mg of acetone per 100 ml of vapor introduced into the instrument. The data employed include a correction of 1.0 ml estimated by a water calibration procedure as being largely due to dead space in the three-way valve and the head of the second syringe during mixing. The intercept near zero of the slopes from any two points suggests that the random error is not large. Each point is the average of at least five determinations.

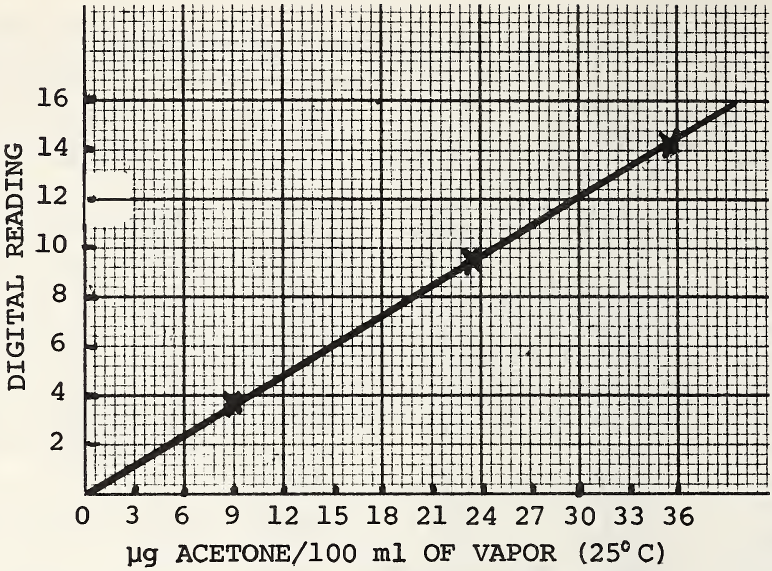


Figure 2 *Digital reading vs Micrograms of Acetone/100 ml (25°C)*

The temperature coefficient of the instrumental digital reading in the neighborhood of 34.5°C was found to be close to 3.5% of vapor concentration per degree.

For a small series of blood bank plasma reference standards the calculated values of the plasma breath ratios were 310, 305, 303, 316, 303, 316 at 34.5° with an average of 309.

Only a few ratios for ordinary plasmas have been determined. The values obtained were somewhat higher (347, 340, 345). As the value for plasma at 34.5°C calculated from whole blood at 37.5°C assuming a ratio of 330 is 329, it is presumed that the lower value for blood bank plasma is the consequence of the effect of additives on vapor pressure.

The values obtained however are sufficient to use in arriving at opinions regarding the concentration of plasma acetone which may interfere with various breath alcohol analyses.

SUMMARY

By use of headspace analysis employing the "Diet Monitor," the normal range of plasma acetone concentrations in subjects free from metabolic disease has been confirmed. In 55 ambulatory diabetic subjects only two were found to have plasma acetone concentrations in excess of 5 mg/100 ml. In 25 specimens from hospitalized subjects having plasma sugar concentrations in excess of 300 mg/100 ml only one had an acetone concentration greater than 5.0 mg/100 ml. Preliminary estimates of the plasma/breath ratio for acetone on blood bank plasma gave an average value of 309 at 34.5°C. The value for normal plasma appears to be a little larger. The temperature coefficient for the vapor concentration of acetone in plasma in the neighborhood of 34.5°C is about 3.5% per degree of temperature change.

REFERENCES

1. Brechner, V. L. and Bethune, R.W.M., Determination of Acetone Concentration in Arterial Blood by Vapor Phase Chromatography of Alveolar Gas, *Diabetes* 14, 663 (1965).
2. Freund, G., The Calorie Deficiency Hypothesis of Ketogenesis Tested in Man, *Metabolism: Clinical and Experimental* 14, 985 (1965).
3. Haggard, H. W., Greenberg, L. A. and Turner, J. M. *Journal Industrial Hygiene and Toxcology* 26, 133 (1944).
4. Harger, R. N. and Turrell, E. S. Use of Dry Syringes for Preparing Specific Gas Mixtures, for Analysis of Certain Gases and as Dry Gas Meters, *Journal of Forensic Science* 10, 239 (1965).
5. Henderson, J. J., Karger, B. A. and Wrenshall, G. A. Acetone in Breath, *Diabetes* 1, 188 (1952).
6. Henry, R. J., *Clinical Chemistry: Principles and Technics*, Hoeber Medical Division, Harper and Row, New York, New York, 1964.
7. Hutson, D., Brochure A. CalDetect Inc., 101 W. Nevin Ave., Richmond, Calif. 94801.
8. Levey, S., Balchum, O. J. Medrano, V. and Jung, R. Studies of Metabolic Products in Expired Air II, Acetone. *Journal of Laboratory and Clinical Medicine* 63, 574 (1964).
9. Rooth, G. and Ostenson, S. Acetone in Alveolar Air and the Control of Diabetes, *Lancet* 2, 1102 (1966).
10. Stewart, R. D. and Boettner, E. A. Rapid Infrared Determination of Acetone in Blood and Exhaled Air of Diabetic Patients, *Nature (London)* 191, 1008 (1961).
11. Stewart, R. D. and Boettner, E. A. Expired-Air Acetone in Diabetes Mellitus, *New England Journal of Medicine* 270, 1035 (1964).
12. Sulway, M. J. and Malins, J. M. Acetone in Diabetic Ketoacidosis, *Lancet* 2, 736 (1970).
13. Tassopoulos, C. N., Barnett D. and Fraser, T. R. Breath-Acetone and Blood Sugar Measurements in Diabetes, *Lancet* 2, 1282 (1969).
14. Widmark, E.M.P. Studies on the Acetone Concentration in Blood, Urine and Alveolar Air. III. The Elimination of Acetone Through the Lungs, *Biochemistry Journal* 14, 379 (1920).
15. Widmark, E.M.P. Studies on the Concentration of Indifferent Narcotics in Blood and Tissue, *Acta Medica Scandinavica* 52, 84 (1920).

The Advantages of Automated Blood Alcohol Determination by Head Space Analysis

G. Machata[1]

The gas chromatographic (GC) determination of blood alcohol is the only routine procedure that enables ethanol to be specifically determined in biological materials and at the same time permits the determination of other volatile components. In routine operation, direct manual injection of the samples, even when the blood samples have been diluted, is not easy to carry out continuously. For this reason, mechanized procedures are to be preferred; particularly the head space technique. The ideal introduction of the sample in gas form produces sharp peaks, high separation performance and a stable base line on the chromatogram.

The specificity of a single GC determination is naturally limited. If, however, the volatile components which come into question are examined more closely, there are only a few that must be differentiated. Such substances are acetaldehyde, acetone, iso-propanol, methanol, ethanol and n-propanol. Furthermore, the internal standard must appear separately. By means of diagrams of the relative retention times (RRT) of four different phases – polyethylene glycol 1500 (K), Hallcomid M 18 (H), porapak Q (Q) and porapak R (R) – it can be seen that the phases H and Q are the most suitable for the solution of this problem (Figures 1 and 2). In practice, however, the phase K is the most widely used because of the shorter total duration of the analysis, even though methanol is not separated from the internal standard.

In Europe, methanol is without practical importance in forensic analyses concerned with road traffic regulations. Furthermore, methanol intoxication is relatively easy to recognize due to the circumstances of the case. If such a case is suspected, the analysis of the blood or urine can be carried out without the addition of an internal standard, or another stationary phase can be employed. The chromatogram shows such an analysis on a case of technical solvent poisoning (Figure 3). In principle, SCOT- or WCOT-columns could be employed to obtain a higher separating performance. These capillary columns require a flow-splitter or a special adaptor in the gas chromatograph. A long-term trial of these columns in routine operation has not yet taken place.

A further improvement is the introduction of column fillings having carbon as the support material. Coating the carbon with polyethylene glycol 1500 brings about an excellent separating performance and enables the analysis time to be reduced. A reduction of one minute in the analysis time gives a time saving for 1000 analyses (in each case double determinations) of 33 hours, or approximately four working days.

---

[1] Professor at the Institute of Forensic Medicine, Chemistry Department, Sensengasse 2, Vienna, Austria.

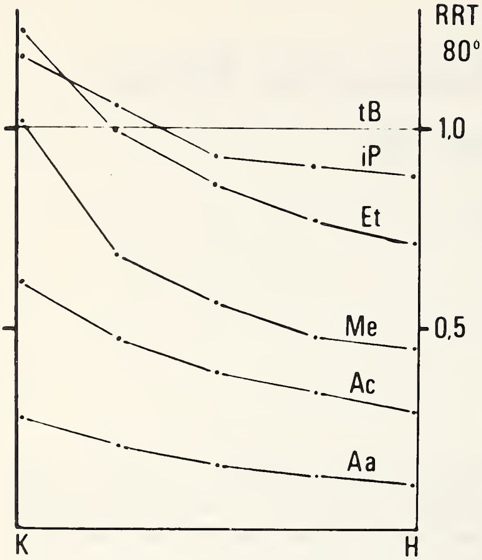


Figure 1 *Relative retention time (RRT) on stationary phase K (Polyethyleneglycol 1500) and H (Hallcomid M 18) of five substances in relation to t-Butanol (t-B).*

Aa – Acetaldehyde
Ac – Acetone
Me – Methanol
Et – Ethanol
iP – iso-Propanol

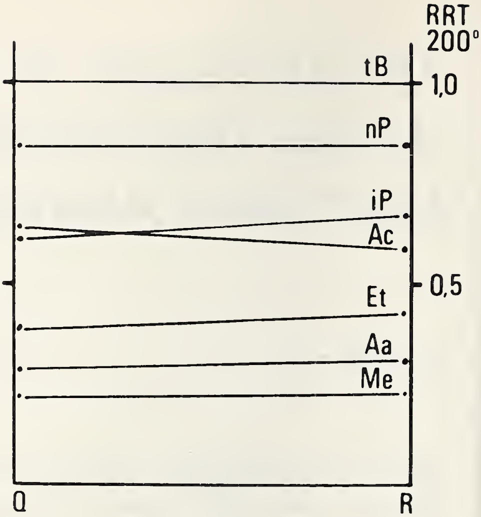


Figure 2 *Relative retention time (RRT) of Phase Q (Porapak Q) and R (Porapak R).*

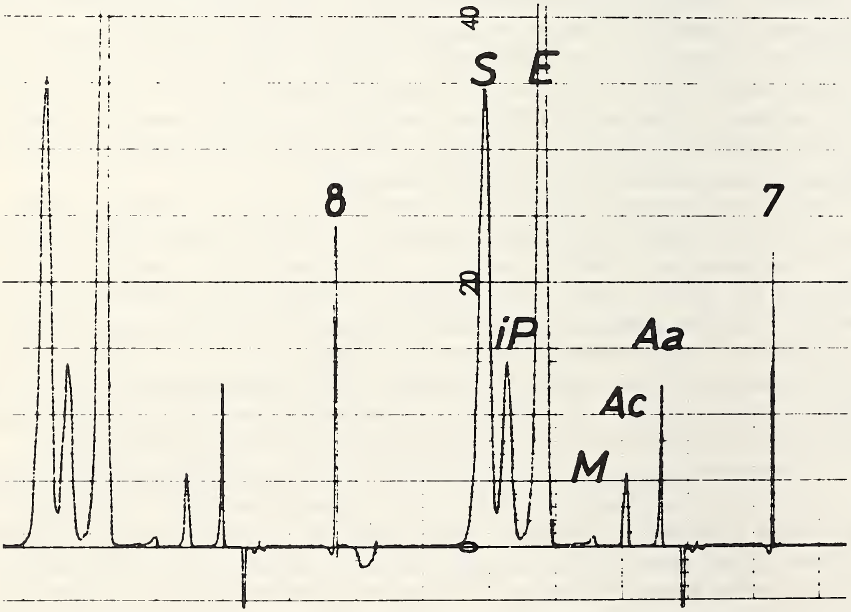


Figure 3 *Analysis of blood after intoxication with technical alcohol (S reference substance: t-Butanol) on Hallcomid with F 40.*

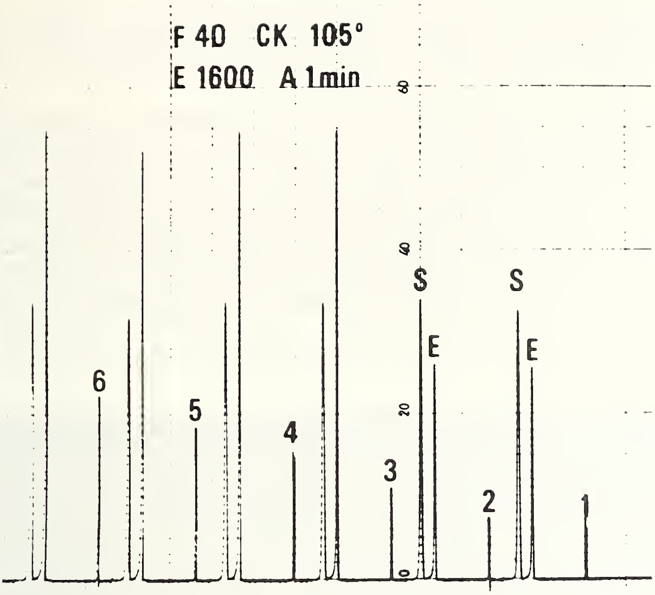


Figure 4 *Routine analysis of blood alcohol; F 40, Column CK (Polyethyleneglycol 0.4% on Graphite 60/80 mesh); analysis time 1 minute.*

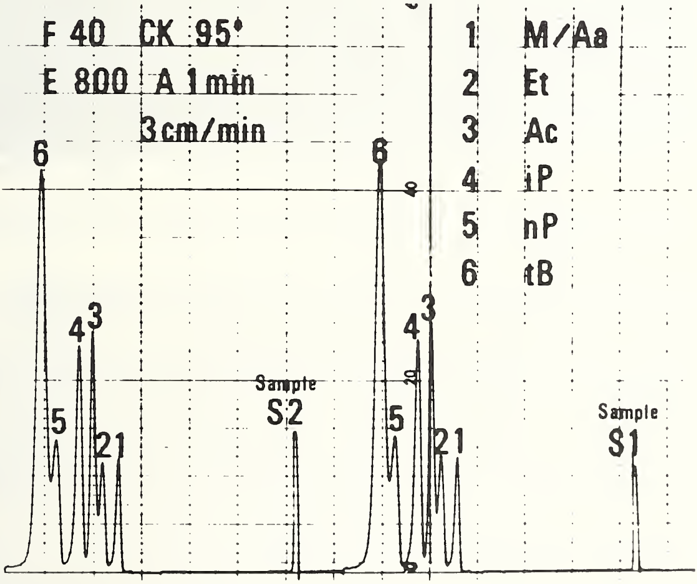


Figure 5 *Analysis of a mixture of different volatile substances; F 40, Column CK; chart speed 3 cm/min, analysis time 1 minute.*

In practice, an analysis time of only one minute is sufficient and the same separating performance is obtained as for a normal carbowax filling (Figure 4). By selecting a relatively low column temperature, all substances of interest can be separated in a relatively short time (Figure 5).

For quantitative determinations, an internal standard is absolutely necessary to maintain high accuracy and to carry out a continuous check on the functioning of the instrument. Tertiary-butanol has been chosen for this purpose because its vapour pressure curve is parallel to that of ethanol and a change of temperature does not alter the ratio of the vapour quantities to any appreciable extent (Figure 6) (6, 7). An internal standard which meets all requirements is difficult to find since it must not have too long a retention time (total analysis time) and must not be present in the sample under normal circumstances. Also, the particular requirements of forensic medicine must be taken into account (e.g. putrefaction alcohol, solvents).

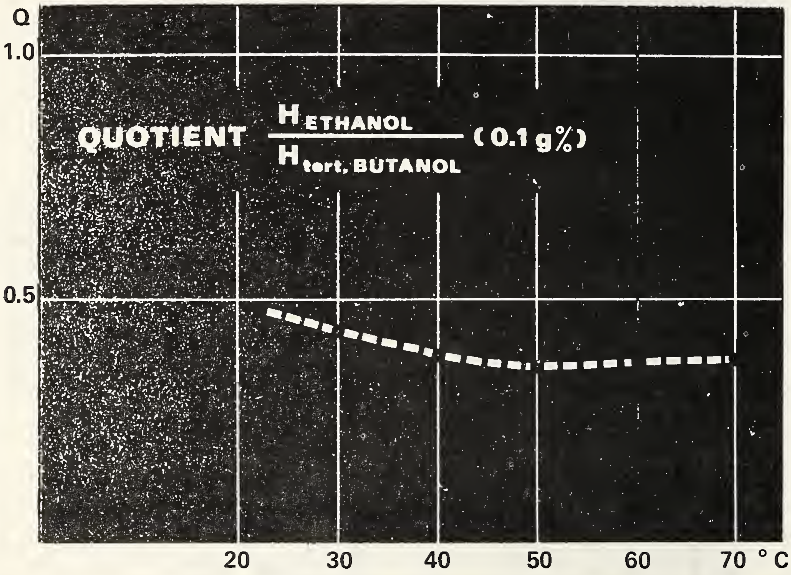


Figure 6 *Relation of the Quotient of the vapour pressure from Ethanol and t-Butanol versus temperature.*

Quantitative determination is carried out by determining the ratio of alcohol to internal standard. At the same time, the internal standard can be used for the determination of other volatile substances. For manual evaluation and particularly with the automatic procedures, conversion factors for the calculation of the blood alcohol concentration must be taken into account to allow for the various types of sample, *i.e.*, serum or blood-containing serum (3). The condition of the blood (water content) must also be taken into account so that the original alcohol content (referred to as normal water content) can be determined (2). For this, two procedures are recommended:

1. When alcohol is present, blood also contains intermediate acetaldehyde. This acetaldehyde is bound to the erythrocytes of the blood and is only released by heating to 60°C when the labile thermobands are broken (9). The quantity is dependent upon the number of erythrocytes and is thereby proportional to the quantity of blood. The

acetaldehyde content is independent of the quantity of alcohol present and is proportional to the Widmark degradation factor B. The peak height of the acetaldehyde therefore gives a good indication of the condition of the blood and can be employed in the evaluation.

2. The alteration of the vapour pressures of volatile components at a given temperature is dependent upon the water content of the sample. The relative alteration of the peak height of the internal standard is proportional to the condition of the sample and is a direct measure of the water content. With manual evaluation, the correction factor can be taken in discrete steps from a table (1). With electronic data handling (EDH) evaluation, a "floating factor" has been in use for several years which allows a conversion for every vapour pressure (Figure 7).

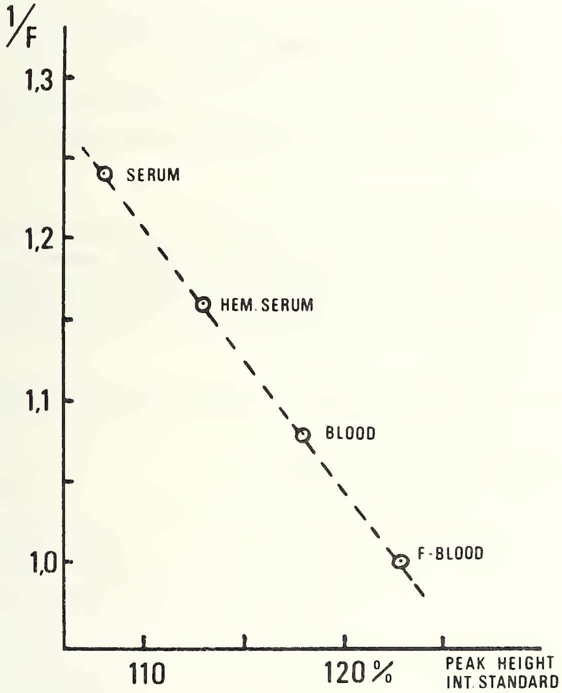


Figure 7 *"Floating factor" for correct calculation of blood alcohol in samples with different water content.*

This is particularly important in routine determinations in forensic analyses where fresh serum, haemolyzed blood samples, fluoride treated blood and congealed corpse blood must all be analyzed.

With this procedure, automatic sample recognition is made and the blood alcohol concentration corresponding to normal blood is calculated exactly. Statistical comparisons of 10,000 single determinations of fresh, random samples gave a mean value difference of 5%, when compared to two other procedures – Widmark (W) and alcohol dehydrogenase (ADH) (Table I). This difference can be noticeably reduced if the second method is automated.[2]

[2] The author thanks the mentioned Institute of Forensic Medicine for valuable supporting data.

TABLE I *Mean Differences between Gas Chromatographic, Widmark and ADH Method*[a]

Method	N	Alcohol Level: mg/100g	Mean Differences: mg/100g
GC/W (Göttingen)	400	> 100 < 100	4.7 3.2
GC/ADH (Aachen)	500	Mean 148	3.6
GC/ADH (Duisburg)	500	Mean 166	3.2
GC/ADH (Münster)	600	Mean 170	3.1

[a] From several institutes of forensic medicine in the German Federal Republic.

With the automated head space procedure (5, 8), the relative standard deviation for a single sample employing an internal standard is ±0.5%, while for alcohol alone a value of ±0.7% can be obtained. The deviation of the single values, calculated from double determinations on 2,000 random samples is ±4.3% (4) (Table II).

TABLE II *Precision Data on Blood Alcohol Analysis by GC with the F40.*

N	Alcohol Level: mg/100g	Standard Deviation	Types
120	100	± 0.7%	Ethanol, Peak Height, Aqu.
120	100	± 0.5%	Q (Ethanol/Standard), Aqu.
1000	50	± 2.0%	Serum (Q)
270	100 – 140	± 1.6%	Serum (Q)

According to the legal requirements in the majority of European countries, the blood alcohol level is the determining forensic factor. A respiratory alcohol determination must be converted to the blood alcohol content. The exact chemical determination of the respiratory alcohol is analytically possible, but the conversion to the exact blood alcohol value is not easy due to physiological factors. The varying proportion of alveolar air, the random influence of the respiratory volume and the ratio of respiratory alcohol to respiratory air must all be taken into consideration.

At the present stage of development of instrumental analysis, the GC head space technique is the optimum method for the determination of the blood alcohol concentration. Also, no other analytical method will be available in the foreseeable future which will be better or can replace this technique.

REFERENCES

1. Battista, H. J., Automatische Differenzierung der Blutproben und Zuordnung der Korrekturfaktoren bei der computergesteuerten gaschromatographischen Blutalkoholbestimmung. Z. Rechtsmedizin 72, 278 (1973).
2. Brettel, H. F., Der Korrekturfaktor bei der gaschromatographischen Leichenblutalkoholbestimmung. Blutalkohol 10, 120 (1973).
3. Göke, G., Vollautomatische Blutalkoholbestimmung mit einem Gaschromatographie-Datensystem. Blutalkohol 10, 281 (1973).
4. Greiner, H., Die Streuung der gaschromatographischen Bestimmung des Äthylalkohols im Serum innerhalb des Routineverfahrens. Blutalkohol 10, 236 (1973).
5. Jentzsch, D. H., Krüger, H., Lebrecht, G., Dencks G. and Gut, J., Arbeitsweise zur automatischen gas-chromatographischen Dampfraum-Analyse. A. anal. Chem. 236, 96 (1968).
6. Machata, G., Über die gaschromatographische Blutalkoholbestimmung. Blutalkohol 4, 252 (1967).
7. Machata, G., Determination of Alcohol in Blood by Gas Chromatographic Head Space Analysis. *Clinical Chemistry Newsletter* 4, 29 (1972).
8. Machata, G., Über die gaschromatographische Blutalkoholbestimmung. II. Mitteilung. Blutalkohol 7, 345 (1970).
9. Machata G. and Prokop, L., Alkoholabbau und Acetaldehyd. Blutalkohol 8, 281 (1971).

A Comparison between the Gas Chromatograph Intoximeter and a Direct Blood Analysis

Martin H. Breen,[1] Kenneth F. Siler, and Dan S. Pearce.

The realiability of breath alcohol analysis for the determination of the blood alcohol level (BAL) depends upon two factors: the analytical reliability of the breath alcohol analysis itself, and the constant factor used for conversion of the breath alcohol concentration to blood alcohol concentration. Both factors are tested by examining statistically, in an appropriately large series, the closeness with which breath alcohol analyses predict actual BAL. The correlation between breath analysis derived BALs and those obtained by direct blood analysis, has been considered as the measure of the reliability of breath alcohol analyses for the indirect determination of blood alcohol concentrations, and has been extensively studied (2). The following is a report of such a correlation study using the Mark II Gas Chromatograph Intoximeter (GCI).

PROCEDURE

Breath samples from 206 subjects were analyzed in duplicate, results of each analysis not varying by more than 0.02% blood alcohol. Blood samples were then obtained from the subjects and subsequently analyzed in duplicate by modification of the method of Kozelka-Hine (3), results of each analysis not varying by more than 0.01% blood alcohol.

The Gas Chromatograph Intoximeter was calibrated with a known simulator solution, always within 6 hours prior to use. Operator blank and stimulator sample were always analyzed after test samples from a subject or group of subjects.

Statistical Analysis

The purpose of statistical analysis was to measure the accuracy of the GCI with respect to its corresponding BAL. Two types of accuracy were evaluated: 1) experimental accuracy, where GCI results were compared to their respective BAL, and 2) predictive accuracy, where the BAL was estimated by the GCI results. Experimental accuracy is based upon a statistical procedure which analyzes the differences between the GCI results and the BAL. Predictive accuracy complements experimental accuracy by testing the GCI's ability to estimate the BAL across the entire spectrum of results. Both types of accuracy are important in evaluating the design of the GCI and in substantiating the case for its use in proving legal issues.

---

[1] Criminalist, Orange County Sheriff's Department, Laboratory of Criminalistics, 550 North Flower St., Santa Ana, California 92702, U.S.A.

Standard statistical analysis of the entire test results was used to establish experimental accuracy. This analysis was also applied to several stratifications of the same test results. Such analyses focus on the experimental differences to show the range of errors and the direction of errors.

Predictive accuracy was determined by simple linear analysis (1). It provided additional insight into experimental accuracy and determined a mathematical relationship between the GCI results and their corresponding blood alcohol level.

RESULTS AND DISCUSSION

A comparison between the GCI blood alcohol values as obtained from the 206 subjects and a comparison of these values to their corresponding direct blood values is portrayed by the histogram shown in Figure 1. The results are seen to be approximately normally distributed.

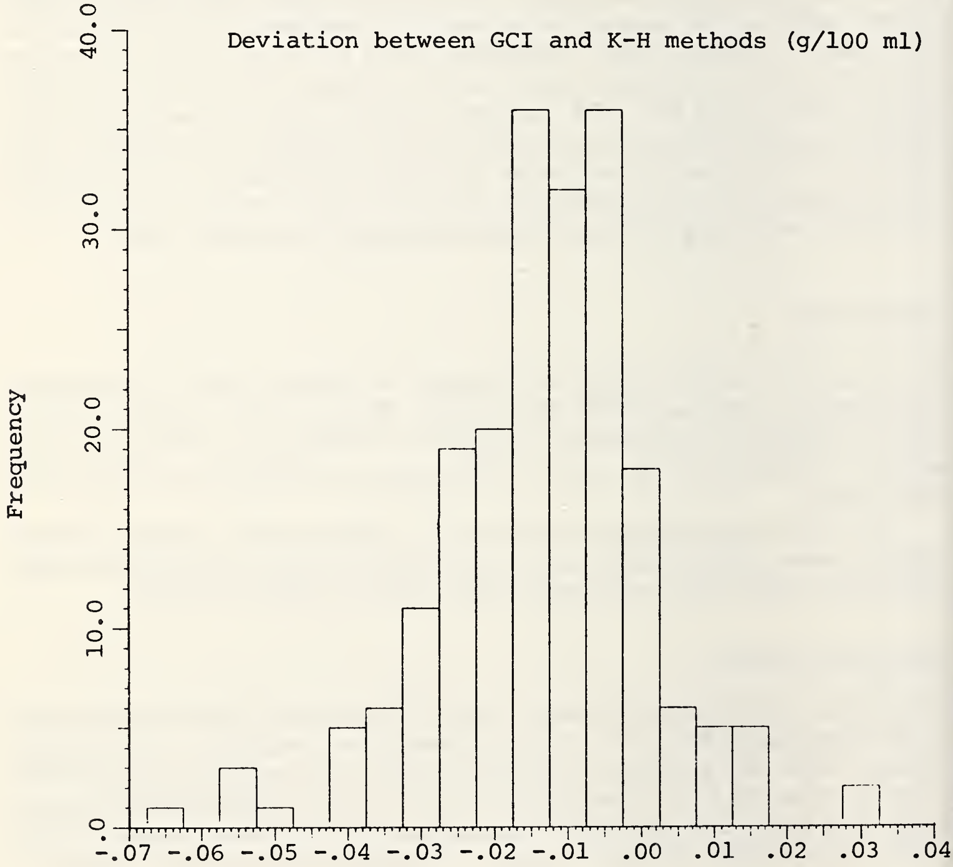


Figure 1 *Histogram grouping number of samples by amount of deviation between the GCI and Kozelka-Hine methods.*

The GCI averaged 0.013% lower than a direct blood analysis with a standard deviation of 0.014. The range of errors was from –0.068% or +0.030%, with 91% of the results showing a GCI result equal to, or less than, its corresponding BAL. This is significant in that it demonstrates that the GCI tends to produce results lower than the corresponding blood alcohol level. This suggests that the alcohol distribution ratio of 1/2100 may be too low.

Through all the blood alcohol ranges the mean deviation was consistently negative. This demonstrates that GCI results are consistently lower than the corresponding BAL. The mean deviation tends to become more negative as the BAL increases (Table I).

TABLE I *Analysis of Percent Differences Between GCI and Kozelka-Hine Methods*[a]

BAL g/100 ml	N	Mean Deviation	Standard Deviation	Range of Differences	Mode
.032-.099	13	-0.008	0.006	-.020-+.004	-.006
.100-.149	47	-0.011	0.009	-.032-+.011	-.008
.150-.199	82	-0.011	0.013	-.038-+.030	-.023
.200-.249	45	-0.017	0.017	-.054-+.030	-.016
.250-.299	15	-0.025	0.021	-.068-+.007	-.067
.300-.322	4	-0.029	0.014	-.042- -.008	-.041
Total (summary)	206	-0.013	0.014	-.068-+.030	-.013

[a] Kozelka-Hine result is subtracted from the average GCI result.

The predictive accuracy of the GCI is shown in Table I and Figure 2. A simple linear regression line was computed with the GCI result being the independent variable. Table I provides the results of the regression analysis. The coefficient of determination (square of the multiple regression coefficient) indicates that 92.5% of the variation between the two methods is explained by the GCI result. The regression equation reflects the expectation of lower GCI results compared to their corresponding BAL and indicates an increasing deviation between the two methods as the BAL increases. The standard error of coefficient is relatively small and the t-statistic shows that the coefficient (1.017) is highly significant (above the .01 level of significance). The fact that the coefficient is greater than 1.000 suggests that the 1/2100 ratio used to translate breath analysis to a blood alcohol reading is too low. The increasing deviation between the GCI result and its corresponding BAL, as the blood alcohol level increases, is a phenomenon that can be explained by an incorrect value for the 1/2100 ratio.

TABLE II *Regression Results*

Equation: BA = 1.017 GCI + .011	Standard Error of Coefficient: .020
Multiple Regression Coefficient (R): 0.9617	t – Statistic: 50.95
Coefficient of Determination (R^2): 0.9249	Degrees of Freedom: 205

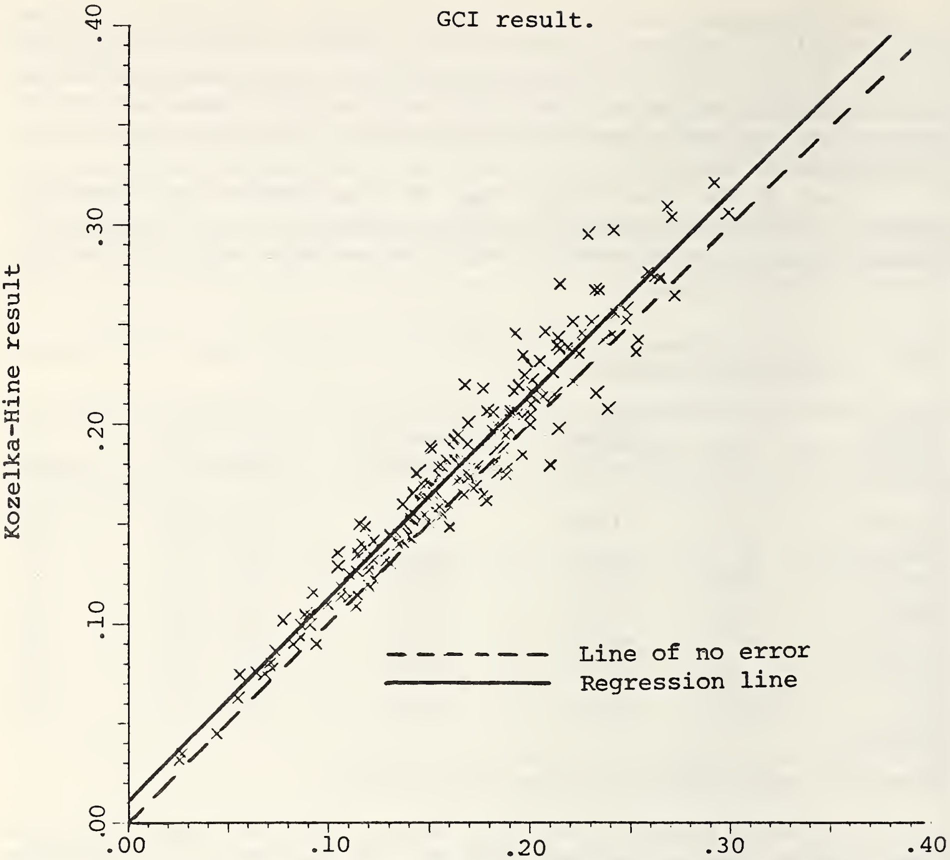


Figure 2 *Plot of observations with regression line: comparison of GCI and Kozelka-Hine methods.*

In Figure 2 the 206 observations are plotted with the regression line and line of no error superimposed. The plot confirms the high experimental accuracy of the GCI. Also the narrowness of the spread of test deviations emphasizes the high level of predictability of the BAL from the GCI. The spread tends to increase as the BAL increases. Examinations of observations above the line of no error indicates that 91% of the GCI results are equal to, or less than, their corresponding BAL.

CONCLUSION

The GCI demonstrated a high level of accuracy: both experimental accuracy, where the GCI results were compared to their respective BAL; and predictive accuracy, where the BAL was estimated by the GCI results. Results also indicated that the 1/2100 ratio is too low, as indicated by the GCI coefficient (1.017) being greater than 1.000.

REFERENCES

1. Alder, H. L. and Roessler, E. B. *Introduction to Probability and Statistics.* W. H. Freeman and Company, San Francisco, California, 1972.
2. Committee on Medicolegal Problems, American Medical Association. *Alcohol and the Impaired Driver.* American Medical Association, Chicago, Illinois, 1968.
3. Kozelka, F. L. and Hine, C. H. Method for Determination of Ethyl Alcohol for Medicolegal Purposes, *Industrial and Engineering Chemistry*, Analytical Edition, 13, 905 (1941).

Comparison of Blood and Breath Testing Under Field Conditions

P. C. Noordzij[1]

From a practical point of view the use of breath analysis for determining the blood alcohol concentration (BAC) is very attractive for research under field conditions, for example, in roadside surveys on drinking and driving. There are, however, various reasons why the good results obtained in the laboratory using several different breath analyzing instruments cannot be expected as a matter of course in the field.

The Institute for Road Safety Research (SWOV) has therefore examined a number of breath analyzing instruments, the main aim of the programme being the comparison between breath and blood tests. The breath tests were carried out at the roadside on randomly selected motorists. The blood samples were similarly taken at the roadside but the actual blood analysis was carried out in the laboratory.

The breath analysis instruments in Table I have been examined and are classified according to the principle of analysis used.

TABLE I *Breath Analysis Instruments*

Instrument	Analytical Principle
Kitagawa Wright	dry chemical
Ethanographe	wet chemical
Alcolinger Automatic	wet chemical
Breathalyzer 1000	wet chemical
Intoxilyzer	infra-red light absorption
Alco-limiter	fuel cell
Alcohol Screening Device	fuel cell
Alcolmeter (bench)	fuel cell
Alcolmeter (pocket)	fuel cell

---

[1] Research Psychologist, Institute for Road Safety Research (SWOV), Voorburg, The Netherlands

The Kitagawa Wright is a simple instrument not in production. The examples tested were about ten years old. The Ethanographe is a Swiss copy of the Breathalyzer 900. Alcolinger Automatic and Breathalyzer 1000 are automatic versions of this instrument.

Among the fuel cell instruments, the Alco-limiter and Alcolmeter pocket were commercially available. However, all four fuel cell instruments should be considered as development models. The Intoxilyzer is the most expensive of the commerically available models.

DESIGN AND EXECUTION

On receiving an instrument we examined a number of characteristics in the laboratory. The most important were: a) normal working mode and any unusual features; b) stability of calibration and zero setting; c) precision of results when analyzing standard air/alcohol mixtures; and d) manner of taking the breath sample. In some cases, due to lack of time, this programme was not strictly adhered to.

The roadside tests were combined with the surveys on drinking and driving habits which were carried out in 1970, 1971 and 1973 during weekend evenings. A preliminary investigation was carried out in 1968. The general procedure with regard to the breath and blood tests was as follows.

At intervals of about ten minutes a motorist selected at random was asked for his co-operation. This meant that after a ten minute interview the driver was given a breath test, then a venous blood sample was taken, and then another breath test. The instruments were regularly checked during the course of these evenings and thoroughly checked before each weekend. Different procedures were used for carrying out the roadside tests in the successive years of the trials. In 1968 the Ethanographe was used. Only one breath test was conducted prior to taking a blood sample. The blood sample was taken by means of disposable hypodermic needles, stored under refrigeration in little plastic cups and analysed with a Pye gas chromatograph. The blood samples were first screened for their BAC and only the positive samples were subsequently analysed quantitatively.

In 1970 an automatic version of the Ethanographe was used, the Alcolinger Automatic. The blood sample was taken and refrigerated in a hypodermic needle connected to a vacuum reservoir (Venüle).

Due to many blood samples showing coagulation in 1970, other vacuum reservoirs were used in 1971. The blood sample was taken by means of a disposable hypodermic needle which was emptied in a vacuum reservoir (Vacutainer reservoir). The Pye gas chromatograph was replaced by a Perkin Elmer. A modified version of the Alcolinger Automatic was used for the breath tests. The Kitagawa Wright was also used in 1971. Motorists were first screened by means of an Alcolinger Automatic and only motorists with a positive BAC were subsequently tested on the Kitagawa Wright.

The rest of the breath analysing instruments were tested in 1973. A combination of hypodermic needle and vacuum reservoir was again chosen for taking the blood sample (Vacutainer needle and reservoir). The only exception to the normal procedure was with the Alcolmeter pocket version where the test subject blew into the instrument right at the beginning, *i.e.*, before the interview. If the result was positive, the normal procedure was followed using the Breathalyzer 1000 as the breath analysing instrument. If the result was negative, the only further step, besides the interview, was taking the blood sample. Finally, in 1973, people with a positive first breath test had a blood sample taken from both their left and right arms.

With such a procedure, the following information could be obtained from the roadside tests: a) precision of the blood test, including taking of sample, storage and analysis; b) mechanical reliability, particular features with regard to operating, maintenance etc. of the breath analysing instruments; c) precision of breath analysis results including taking of samples; d) accuracy of breath analysis to predict the results of directly measured BAC. It can be seen that the programme of investigation did not include tests for specificity of the analysis or laboratory tests for comparing breath and blood tests.

RESULTS

Only the most interesting findings of the roadside and laboratory tests will be given here.

Laboratory Tests

Repeated analysis in the laboratory of a standard air/alcohol mixture corresponding to a BAC of about 100 mg/100 ml showed that the maximum deviation was less than 5 mg/100 ml for all instruments. The manner in which the breath sample was taken was found to differ considerably between one instrument and another and in some cases differed considerably from the factory specifications. As this point is critical with regard to the whole principle of measurement, a summary of the instruments is given in Table II.

All the instruments except the Ethanographe were calibrated on the basis of the relationship between the alcohol content of breath and blood being 1:2100. The Ethanographe appeared to indicate 10% lower without this adjustment being altered.

Roadside Tests

All the instruments except the Breathalyzer 1000 and the Intoxilyzer showed faults during the roadside tests. Faulty results also occurred in the blood analysis in the beginning of the 1973 investigations as was apparent from extreme differences in results from blood samples taken from both arms of a test subject. The problems were completely overcome by the fourth weekend (it is possible that in previous years such faults went undetected).

The linear correlation coefficient r_{yy} which was calculated from the fourth weekend of 1973 for the results of blood samples taken from both arms of a test subject was 0.995. The standard error in replacing the blood test of one arm for the blood test of the other arm is 5 mg/100 ml. Thus, 1973, only data from the fourth weekend were processed.

The BAC of a blood sample is always an average value of two analyses. The r_{yy} between two analyses on one blood sample is calculated as 0.997 for the 1968 material.

In these and subsequent calculations all observations in which both values are below 10 mg/100 ml were omitted. In addition, all results of analyses of coagulated blood samples were also left out of the calculations. Also, cases in which the test subject admitted to drinking within the previous half hour period were left out of the comparison of breath and blood test. For the comparisons of the Kitagawa Wright and the Ethanographe with the blood test these two latter cases were, however, retained in the calculations since the total number of observations would otherwise have been too small. Cases in which faults were noticed in the breath analysing instruments, an unsatisfactory breath sample was obtained or a fault in operating the instrument was made, were also left out of the calculations.

In the 1968, 1970 and 1971 comparisons between breath and blood tests, the breath test was taken as the average of two readings with the exception of the Ethanographe for which only one measurement per test subject is available. For the 1973 comparisons between breath and blood tests, the average of two breath tests was compared with the average of the blood tests from the two arms of the test subject whenever possible. The precision of the breath analysis results, including sample taking, is expressed as the linear correlation coefficient r_{xx} between two breath tests on one test subject. The accuracy of the breath analysis is expressed by the linear correlation coefficient r_{xy} between the breath and blood test results, the linear regression formula for predicting the blood analysis result $\hat{y}$, and the standard error of estimate sd thereby incurred. Table II provides a summary of these quantities for each instrument.

TABLE II *Breath Sampling by Instrument*

Instrument	Total volume of expired breath	Sample	Check
Kitagawa Wright	max. 750 cc	last 100 cc	automatic
instrument faults[a]	max. 1000 cc	last 100 cc	automatic
Ethanographe	variable	last 52.5 cc	by observation
Alcolinger Automatic			
1st. version[b]	min. 750 cc	last 52.5 cc	automatic
2nd. version[b]	min. 500 cc	last 52.5 cc	automatic
Breathalyzer 1000[b]	min. 750 cc	last 52.5 cc	automatic
Intoxilyzer[c]	min. 2000 cc	last 600 cc	automatic
Alco-limiter[b]	average 950 cc	last 20 cc	automatic
Alcohol Screening Device	min. 2500 cc	sample drawn during blowing volume unknown	automatic
Alcolmeter pocket and bench	average 2000 cc	last 1.5 cc	by observation

[a] The Kitagawa Wright is shown twice because faults that occurred during some weekend nights resulted in increased volume of expired air. This happened to give better comparability of breath and blood testing.

[b] The values given here could only be achieved after structural modifications.

[c] Departing from the instruction manual's advice, the analyst took special care to obtain a maximum reading in the roadside tests. The average total expired volume was therefore greater than 2000 cc.

DISCUSSION

In giving a final judgement of the instruments several aspects have to be accounted for such as checks or modifications on receiving the instruments, maintenance and operating instructions and costs.

A first concern, however, is the performance of the instruments with regard to precision and accuracy. The requirements to be met in this regard depend on the field of application.

It appears that the instruments differ from each other in precision including breath sampling and accuracy (Table III). Possible causes for this include the analytical principle, precision of the measurement, stability of calibration and zero-setting, sensitivity to extraneous factors, breath sampling and physiological variability in the ratio between alcohol content of breath and blood. By excluding test subjects who admitted to drinking within the previous half hour period differences between arterial and venous blood are assumed to be nonexistant.

TABLE III *Precision and Accuracy of Breath Test*

Instrument	r_{xx}[a]	r_{xy}[b]	$\hat{y}$[c]	sd[d]	Number of observations[e]
Kitagawa Wright	0.974	0.865	1.64 x –2.7	22	35
(instrument faults	0.954	0.949	1.01 x +4.2	11	21)
Ethanographe	–	0.978	1.35 x –9.5	9	39
Alcolinger Automatic					
1st version	0.979	0.959	1.30 x –11.5	12	113
2nd version[f]	0.975	0.876	1.32 x +0	23	253
Breathyalyzer 1000	0.987	0.957	0.88 x +15.8	14	25
Intoxilyzer	0.991	0.985	1.16 x –6.6	8	96
Alco-limiter	0.977	0.969	1.35 x –8.5	9	132
Alcohol Screening Device	0.947	0.974	1.34 x –9.5	9	123
Alcolmeter bench	0.932	0.958	1.22 x –0.8	12	70
Alcolmeter pocket	–	0.905	0.97 x +21.8	16	33

[a] Correlation coefficient between two breath tests. With Breathalyzer 1000 and Intoxilyzer, r_{xx} concerns pairs of measurements by a single unit; with the rest of the instruments, r_{xx} concerns pairs of measurements by several units per type of instrument.

[b] Correlation coefficient between breath and blood tests.

[c] Linear regression formula in mg/100 ml.

[d] Standard error of the estimate in mg/100 ml.

[e] The set of observations for calculating r_{xy}, $\hat{y}$ and sd is not identical with the set of observations for r_{xx} since in the latter case absence of a blood sample is unimportant while in the first case sometimes only the result of one breath test was available.

[f] If 8 extreme differences, which imply that the blood test result is unlikely, are omitted the values become: $r_{xy} = 0.933$; $\hat{y} = 1.40\ x - 5.0$; sd = 17.

The laboratory tests showed only minor differences in precision of results when standard air/alcohol mixtures were analysed. The calibration of all fuel cell instruments is less stabile than the rest of the instruments. Figures 1, 2 and 3 illustrate the relation between breath and blood test for three instruments representative of the three analytical principles (Alcolinger Automatic, Alco-limiter and Intoxilyzer). The sensitivity for extraneous factors has not been carefully investigated.

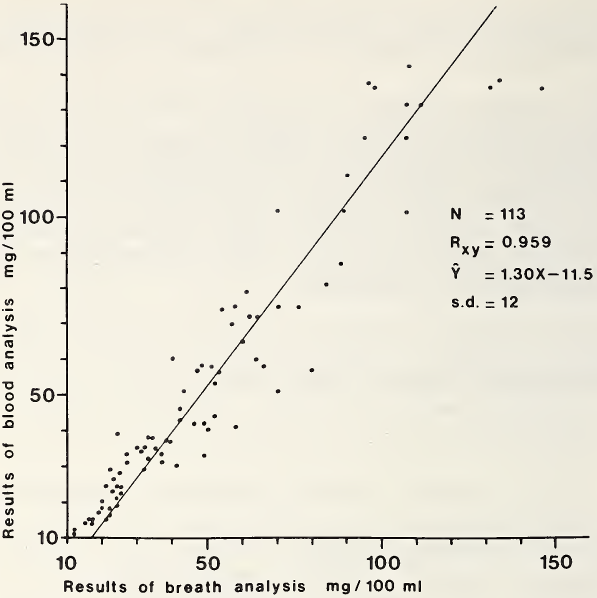


Figure 1 *Relationship between the breath and blood test using the Alcolinger Automatic.*

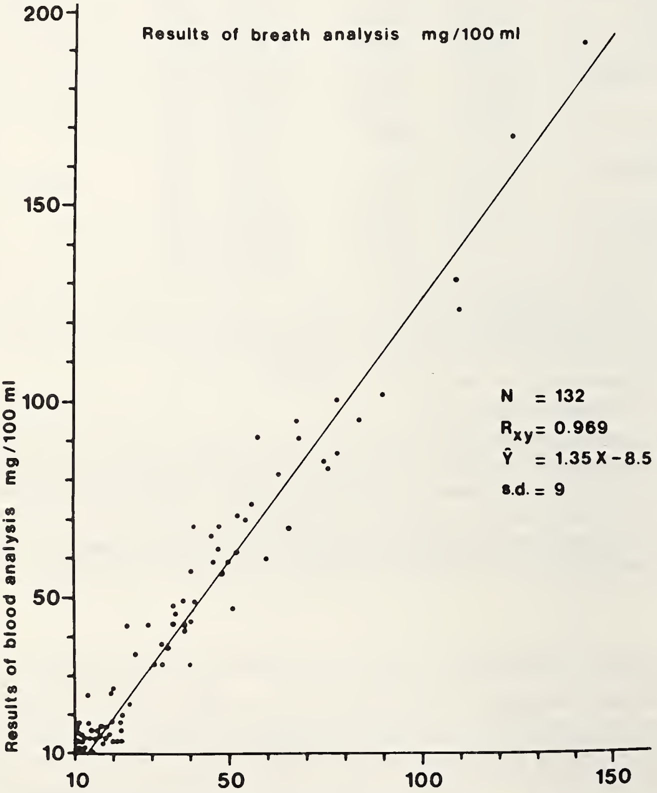


Figure 2 *Relationship between the breath and blood test using the Alco-limiter.*

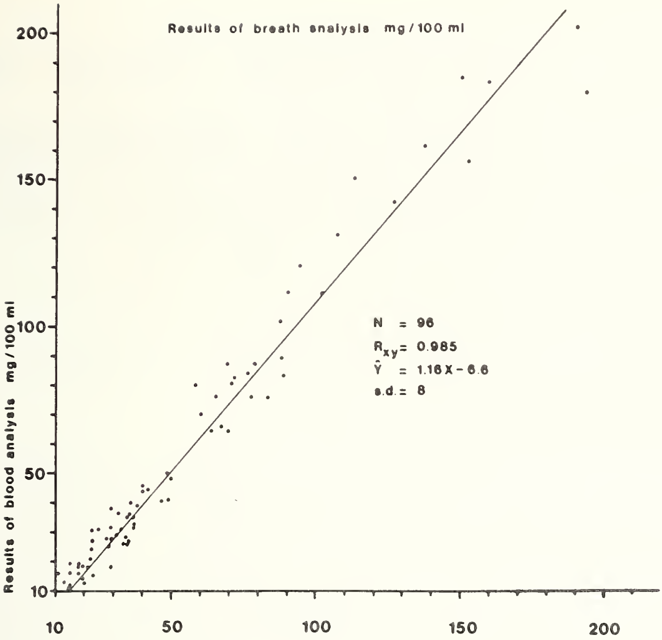


Figure 3 *Relationship between the breath and blood test using the Intoxilyzer.*

With regard to breath sampling it is expected that with increasing expired breath volume, *i.e.*, with a breath sample coming from deeper in the lungs, the accuracy of predicting the blood test from the breath test increases. This is expressed by an r_{xy} approaching 1.0, a small systematic error between breath and blood test results (when calibrated according to the 1:2100 ratio) and with a small sd. Also, a better precision of the breath test can be expected.

The results shown in Table III are roughly in line with the expectations based on the differences in breath sampling between instruments (Table II). For example, with the two instruments that have been used with two different breath sampling arrangements (Kitagawa Wright and Alcolinger Automatic), the larger the expired volume of breath the more accurate the prediction of the blood test.

Furthermore, it hardly mattered if the blood test was predicted by one or the average result of two successive breath tests as long as the same instrument was used. The lack of accuracy is therefore a systematic error per test subject, indicating the breath sampling and/or physiological variability as probable causes. The Intoxilyzer is the best for accuracy and is only slightly less precise than the blood test (r_{yy} for results of blood samples from both arms is 0.995 with a sd of 5 mg/100 ml). With the Intoxilyzer the test subject continued blowing until the analyst observed a maximum BAC reading. In this case most or all of the lack of accuracy has to be attributed to the physiological variability of the ratio between alcohol content of breath and blood. This implies that with the Intoxilyzer the upper limit in accuracy in predicting the blood test from breath testing is approached.

Breath Alcohol Analysis by Gas Chromatography: Two Years' Experience with Field Collected Samples

Lawrence S. Harris,[1,2] C. Nicholas Hodnett, John B. Mullen

Before launching into a detailed description of our current breath alcohol testing program, it would be appropriate to review briefly the conditions which prevailed prior to the introduction of the program in the geopolitical unit under consideration, which is the entire State of Vermont.

Vermont is a rural state, with 500,000 residents and about 20,000 tourists at any given time. The largest community in the state is a city with a population of 38,000. The state has an area of 9.6×10^3 square miles, and there are over 14,000 miles of highways within its borders.

A large segment of Vermont's resident and tourist populations enjoy their favorite alcoholic beverage away from home. This is particularly true in the summer and autumn months. This practice puts a steady stream of drinking drivers on our highways and, because many of our roads are rural, this driving is often done at high speeds.

BACKGROUND TO THE PROGRAM

In the years prior to 1971, the practice of drunk driving could be carried out on Vermont highways with relative impunity. Even if one were apprehended by a duly authorized police officer, there was small chance of eventual arrest, conviction or licence revocation. There are numerous reasons for this state of affairs.

First of all, by state statute, conviction of a contested charge of driving while intoxicated (DWI) required the introduction of a chemical test of either blood or breath – the choice was the respondent's. From the point of view of the intercepted driver the breath test was preferable because, in most jurisdictions, the methods of breath testing were antiquated, poorly administered and therefore open to legal challenge. Thus, with a good lawyer, a driver could nearly always be sure of "getting off the hook" if charged with DWI, regardless of the blood alcohol level at the time of apprehension and testing.

---

[1] University of Vermont and State Department of Health Burlington, Vermont, U.S.A.

[2] The authors are greatly indebted to Mr. Brian MacPherson of the Department of Epidemiology and Environmental Medicine, College of Medicine, University of Vermont, for his assistance with the statistical analyses.

In addition, there is a law in the statutes of the State of Vermont which specifies that any sample of blood or breath collected for the purposes of evidence in a drunk-driving prosecution is to be collected in duplicate, so that the accused driver can have access to an independent laboratory analysis of the test sample. As the law currently exists, the state laboratory is required to retain this 'duplicate sample' for a period of 90 days after the date of arraignment, during which time the respondent and/or his legal counsel can avail themselves of the opportunity for an independent laboratory analysis, if they so desire. Of course, this provision allows defense counsel to take even greater liberties with the evidence; any minor difference between the state's laboratory result and that of the independent laboratory, introduced into evidence in a jury trial, could be inflated far out of realistic proportion for the purpose of discrediting the chemical testimony.

Also, the enforcement of DWI laws in Vermont has become encumbered in recent years by two developments within the legal profession. Firstly, there has been massive immigration of energetic, young lawyers to Vermont, seeking a home and a career in a quiet non-urban environment. Their numbers are such, in fact, that it was recently noted by one astute observer that Vermont now seems to have more lawyers than people. The effect of this excess of legal minds has been to provide eager, aggressive defense lawyers in private practice to represent accused persons in courts of law. In a state which still insists that an accused person has the right to a trial by a jury of his peers, regardless of the nature of the offense, this abundance of lawyers has led to a situation in which a DWI trial before a jury is often given the same attention and weight as a trial for the charge of homicide.

Secondly, there has been an ongoing trend in U.S. jurisprudence toward lenience and humanitarian liberality in the prosecution of certain offenses, and in particular toward those offenses in which the accused may be asserted to be suffering from alcoholism. This trend is clearly reflected in a recent U.S. Supreme Court declaration that alcohol abuse is a disease process – a 'natural' disease. In this context, juries have often been persuaded to be sympathetic toward the accused, on the mistaken thesis that "there but for the grace of God go I".

One result of these legal developments, was the advent of plea-bargaining on a large scale: in a case charged with driving while intoxicated, reduction of the charge to one of reckless driving was the usual course of action by the prosecution. Understandably enough, a secondary result of this practice, at least until the initiation of the federal Alcohol Safety Action Program in 1971, was a perpetually low level of morale and performance of police officers when it came to the pursuit and apprehension of drunken drivers.

To summarize: in Vermont in the years just prior to 1971 the breath testing program was inadequate and open to challenge and repudiation in court; plea-bargaining to a lesser charge was available to those who could afford a lawyer; and the morale of the law enforcement community on patrol on the highways was understandably at a low ebb. The police had little incentive to pursue a drunken driver and, in fact, many reasonable arguments against going to the trouble of apprehension and arrest.

THE BREATH-TESTING PROGRAM

Given the circumstances which I have just outlined, the ideal breath-testing procedure for Vermont is one which provides for the collection of a duplicate sample for each respondent. Because of the 90 day provision in our statutes, the 'shelf life' of the duplicate sample has to be in terms of months, with little or no deterioration in that time-span. Further, because of our widely spread driving population, the system should be one which provides for collection of the specimens at numerous remote sites. It must also provide a method of collection requiring a minimum of technical expertise, inasmuch as budgetary constraints preclude the training and maintenance of a specialized cadre of breath-specimen collecting personnel. Lastly, the overall system has to provide accurate, reliable results which are credible in our courts.

Through late 1970 and early 1971, we investigated several of the breath testing systems then available. We settled on the gas chromatographic method of Forrester's Intoximeters Incorporated – specifically, the "Gas Chromatograph Intoximeter" (GCI) system, utilizing the so-called "Field Collecting Devices" (Crimper Boxes) manufactured by that company.

The analytic method is basically pure gas chromatography. The GCI instrument is designed to accept an encapsulated breath sample which is trapped in a cylindrical tube of soft indium metal. The preset volume of each encapsulated breath sample is 0.25 ml, and all test standardizations are based upon this volume. A photoelectric cell registers the excitation of a flame at the distal end of the chromatographic column, imparting to a flat-bed recorder an electronic signal, the strength of which is proportionate to the quantity of combusted eluate. The tracing which results is thus quantitative and qualitative. The major peak shown is identified as ethanol by its Rf value, and its quantity is calculated on the basis of the peak deviation from the baseline. Minor peaks with other Rf values, indicating the presence of methanol or acetone, for example, are possible to identify. We use a standard solution of ethanolic vapor as an internal standard. Our external standardization uses two methods, both of which give us excellent agreement: one is based upon simultaneous venous blood and breath samples from volunteer drinking subjects; the second is based upon prepared, analytic reagent solutions, as recommended by the manufacturer. Intercurrent standardizations were routinely conducted to check the reproducibility of the method in respect to internal and external standard solutions. Each standardization method gave us reproducibility within 95% confidence limits.

The breath samples on which we base this report were all law enforcement samples, and all were collected in the field by means of a crimper box by a trained, full-time officer of the law.

One of us (LSH) conducted classes for several months in 1970 through 1972, instructing a course in the theory and practice of breath sampling by crimper box. These classes were conducted at a Police Training Academy and were attended by state, city and town police officers, as well as sheriffs and their deputies.

The use of the crimper as a breath sampling device is straightforward and simple. With few exceptions our law officers were able to become proficient within the hour or two of instruction.

The crimper box with indium tube and template in place is preheated for 15-20 minutes prior to sampling. The heat source is internal and is motivated by standard AC house current or by 12 volt DC circuitry, for example from a dashboard cigaret lighter in a patrol car. The achievement of proper heat is indicated by the thermostatic activation of a light signal. The properly connected tube assembly consists of a waste bag (volume 1100 ml) connected in parallel with the indium tube encased in its template. A filter is interposed at the proximal end of the indium tube. On filling the waste bag with breath from the 'physiologic dead space', the remaining breath in that exhalation should consist of alveolar breath, and thus should best reflect the alcohol concentration of deep lung air. The sampling is done near the end of such an exhalation, and is performed by firmly squeezing the handle of the instrument, which closes the jaws of the device on the indium tube at four sites, thus sealing the tube into three individual segments of 250 microliters volume each. The reverse passage of waste bag contents is blocked by a one-way valve, and we recommend using a similar one-way valve at the distal end of the indium tube to preclude the inhalation of room air into the sampling tube.

Over 3,400 law enforcement breath samples were collected and analyzed in the two years under consideration. As noted, throughout this period intercurrent external standards were used to verify our test results, in addition to the internal standards which were run with each sample tested.

Samples were transmitted to a central laboratory by certified mail. Each sample was divided into its respective segments, and the distal and middle segments were analyzed and formed the basis of our reports to the prosecuting attorneys in each case. Our instrumentation and calibration gave us results to three significant figures – as equivalent to a blood alcohol concentration (BAC) in thousandths of a g/100 ml. The results from the distal and middle segments were averaged and the mean value thus calculated was rounded to two digits – equivalent to hundredths of a g/100 ml BAC. This average value was reported to the prosecutor. The proximal sample segment was stored at room temperature for possible future use by the respondent, and was kept for at least 90 days from the day of arraignment.

Method of Evaluation

An attempt was made to evaluate the program as it operated during the calendar years 1972 and 1973. This evaluation may be limited in certain respects, but overall, it should provide a set of data with which to appraise the worth of this particular system of breath alcohol analysis for law enforcement purposes.

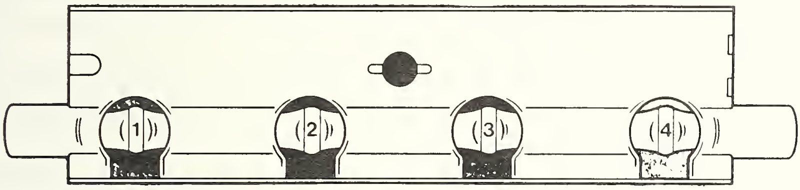
One major limitation to a fuller evaluation is the absence of the knowledge of what the true BAC was at the time of breath sampling in any given test. However, other studies (1,2,3,4) have demonstrated these blood/breath alcohol ratios with this instrumentation, and with the routine use of internal and external standards, we believe we can be quite confident that the equivalent BACs determined by this breath method give reliable figures, at least when subjected to the criteria described below.

This evaluation encompasses and surveys the entire methodology, from the manufacture of the indium tubes to the actual gas chromatograph (GC) analysis itself. Each of the intervening processes such as sampling, the physical handling of the specimen in transit, the passage of time between collection and analysis, the gas chromatographic process, the electronic instrumentation and the recording of the results also represent a source of possible error. Thus, our task is one of defining the precision and reliability of the entire method, from beginning to end.

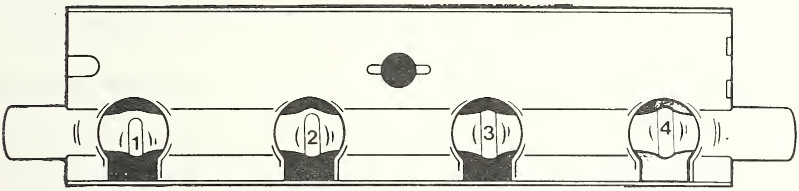
Part of this evaluation will be descriptive and part will be statistical. More than two years' experience has provided insights into practical, everyday problems in the method, and over that period enough duplicate and triplicate breath samples have accumulated to provide a data base for a statistical definition of precision, reproducibility and reliability.

Recognizable Sources of Error

Early on in our work, we noted the occurrence of an occasional sample in which one segment, usually the distal third of the tube, showed a low alcohol content when compared to the middle and proximal segments. This phenomenon occurred infrequently enough, but each occasion was disturbing, since each represented the potential loss of the specimen for prosecution purposes. We discovered after a short time that each of these so-called 'defective crimp' samples presented a similar physical appearance on close inspection. Figure 1 illustrates the nature of the flawed samples. In a close-up (Figure 2), using an early version of the template with a circular opening, a mark can be seen where the misaligned template was pinched between the jaw faces. The indium tube, was often not completely sealed at this site, and in such a condition, the contents of at least one segment were lost, either immediately or over the next few hours. We recommended that the manufacturer redesign the template, and this was done, as noted by a comparison of the designs in Figures 1 and 2. We have called this the "defective crimp error".



Properly Crimped



Improperly Crimped

Figure 1 *Indium tubes in templates.*

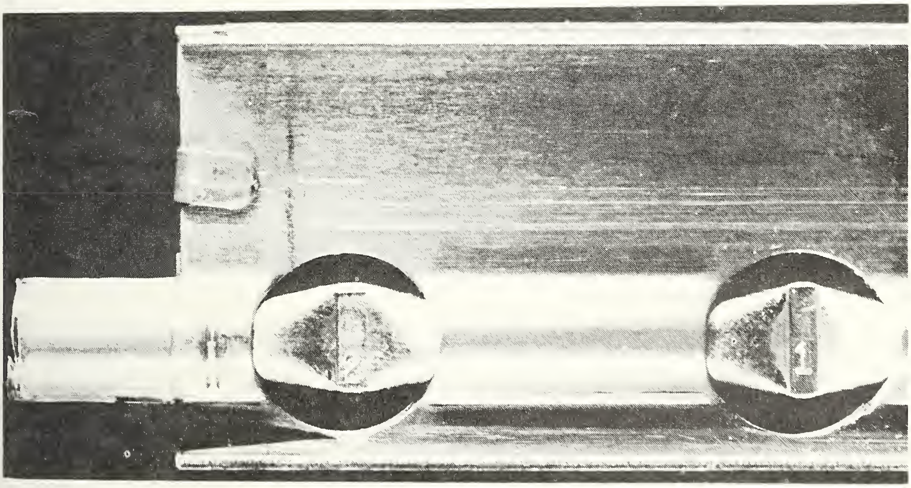


Figure 2 *Defectively crimped breath samples.*

Other sources of error became apparent to us as well: one was found to be due to maladjustments within the crimper box, usually within the adjustment of the grip-handle. This problem manifested itself as uniformly incomplete crimp-marks on the indium tube and with associated low or absent BAC values across all segments. This source of error was corrected by a schedule of maintenance which routinely checked this feature on the crimper boxes from time to time.

Each of the sources of error just noted produced a low reading of equivalent BAC – a false negative result.

Two other factors led to false positives and to elevations of the apparent BACs which are simply not credible on physiologic grounds. The first of these is the practice of sample collection in a cold indium tube. This results in condensation of alcohol in physical droplets, if alcohol is present, and on analysis these droplets are vaporized into concentrations equivalent to BACs of one g/100 ml or more.

A second source of a false positive result is the infrequent instance in which the test subject actually belches during the exhalation phase, or in which regurgitation of gastric contents into the mouth of the respondent has occurred just prior to or during the sampling process. In cows, we call this process rumination, and that term should apply here; we call it the 'ruminative error'. In our experience, this error also results in physiologically impossible readings.

Lastly, there are a variety of sampling process errors which occur at a random rate within the larger sample population. We have traced most of this last group of errors (all of which are of the false negative variety,) to a very small group of slow learners in the law enforcement population. These errors represent a minute but intractable source of trouble. We have attributed their presence to the thermodynamic laws of entropy.

It should be noted that each of these sources of error result either in decreasing the equivalent BAC, thus erring on the side of the respondent, or to invalidation of the sample, resulting in no prosecution. Table I presents the occurrence of these particular errors which we found could be recognized and identified on descriptive bases or by deduction. It can be seen from this Table that the defective crimp error makes up a major portion of the overall occurrence of such errors, and that this error source has largely been eliminated, leaving a residual failure frequency of 1.6%.

One additional problem should be mentioned at this juncture which was first reported to us by law officers in the field. They informed us that about one person in 200, apprehended for DWI charges, cannot be tested by this breath method because of chronic pulmonary disease, specifically chronic obstructive pulmonary emphysema. In such instances, the law officer must obtain a blood sample for alcohol analysis, which fortunately is legally possible under our current statutes. It should be noted, however, that such cases do not appear in our statistics, and that the absence of these figures represents a deficiency in the breath analysis program. Perhaps such a failing will appear in any breath testing program, but it should be recognized.

Statistical Evaluation

In the two years of sample collection, 3,438 breath samples were collected and analyzed. Of these, 268 (7.8%) were not used as prosecution evidence because of gross sampling errors which were recognized on the bases just outlined.

Thus, 3,170 samples (92.2%) were deemed valid for evidenciary use. All of these were available to us in this study in duplicate, and 2,880 were available in triplicate. It should be remembered that our analyses of 'unclaimed' triplicate segments took place

TABLE 1 *Occurrence of Recognizable Error in the Measurement of Breath Samples. N=3438*

Type/Source of error	Per cent frequency	Correction
"Defective crimp"	6.2	Eliminated by template redesign
Maladjustment of crimper	0.5	Routine maintenance
Cold indium tube	0.3	Re-educate testers
Belching/"rumination"	0.2	Re-educate testers
Irrational/entropic	0.6	Probably none
TOTAL	7.8	

at least 90 days after the initial testing of the first two segments of the sample, again in accordance with Vermont law.

The best statistical evaluation of such data is one based on coefficients of correlation. The data presented below are based on comparisons of the distal and middle segments of each breath sample in the first instance, and on the proximal segment and the average of the distal and middle segments in the second instance. It should be remembered that the proximal segment was analyzed at least 90 days after the first analysis of the distal and middle thirds of the sample. Thus, the second set of data may also reflect the 'shelf life' of the sample, that is, the effect of the passage of more than 90 days at room temperature on alcoholic vapors enclosed within the indium tube segments.

In the first comparison (between the distal and middle segments of indium tube encapsulated breath samples), where N = 3,170, the coefficient of correlation (r) equals 0.999. A regression analysis (Figure 3) based upon these data (middle segment versus distal segment) shows a tight fit of values within the 95 and 99% confidence limits.

However, if the security of a 99% confidence level is desired, the standard error of these data increases to plus-or-minus 18% at BAC levels of 0.10 g/100 ml. At such confidence intervals, precision is reduced further, as can be seen in Figure 3.

Moreover, a closer analysis of the data, particularly those points at or near our statutory definition of DWI (0.10 g/100 ml) reveals that an error of ±13% exists at this level (Figure 4). Thirteen per cent of 0.10 g/100 ml is 0.013 g/100 ml. Thus, assuming the usual scientific standard of a 95% confidence limit, we must admit to a lack of precision of 13% at the critical enforcement level which defines the legal offense.

Figure 4 shows how such a per cent error distorts the precision of the lower readings of BAC. It is most disturbing that precision is lost in this range, not only for Vermont with its 0.10 law, but for those jurisdictions with 0.07 and 0.08 statutory levels, where the per cent error is even larger.

At the same time, we should point out that the per cent error falls to clearly acceptable levels of BAC in higher ranges of measurement, and that the precision of the method at these levels, is correspondingly better.

In a comparison of test results between the mean of the first two segments and the most proximal segment (Figure 5), the latter test carried out at least 90 days after the former, our calculations indicate a correlation coefficient of .998, slightly less than

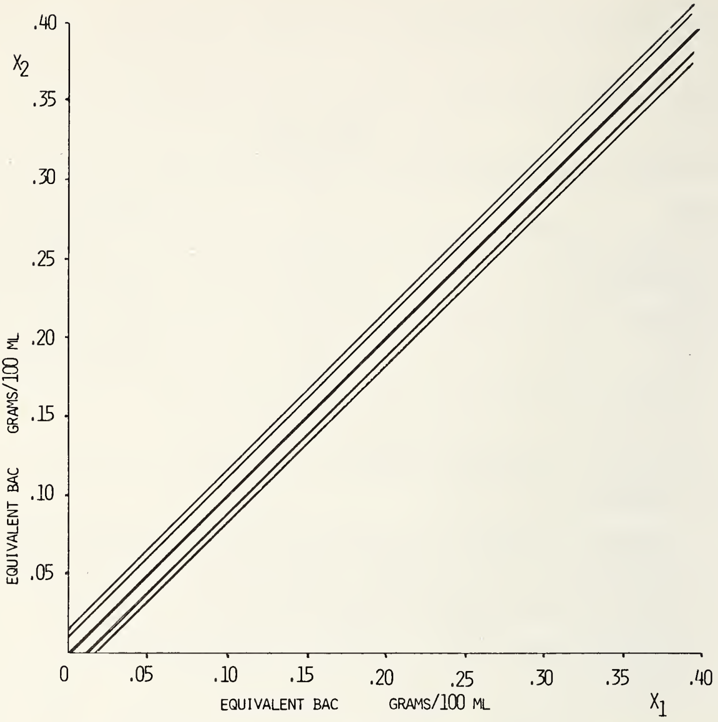


Figure 3 *Regression of X_2 on X_1 with 95% and 99% confidence limits. N = 3170, correlation coefficient = .999. X_1 = distal segment, X_2 = middle segment.*

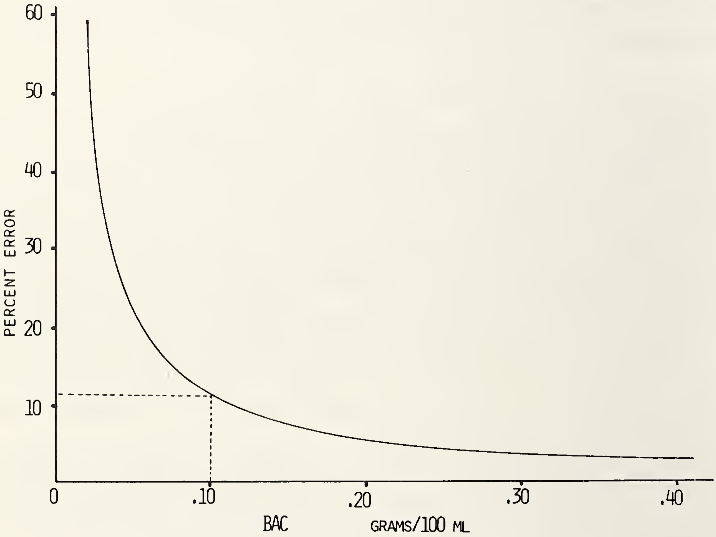


Figure 4 *Per cent error by BAC – assuming 95% confidence limits.*

in the previous instance. The standard error of these data, based upon 2,880 sample comparisons, is plus or minus 20 per cent of the 0.10 g/100 ml BAC level – or 20 mg/100 ml, again with 95% confidence levels. At the 99% confidence level, the error of these data is 26%.

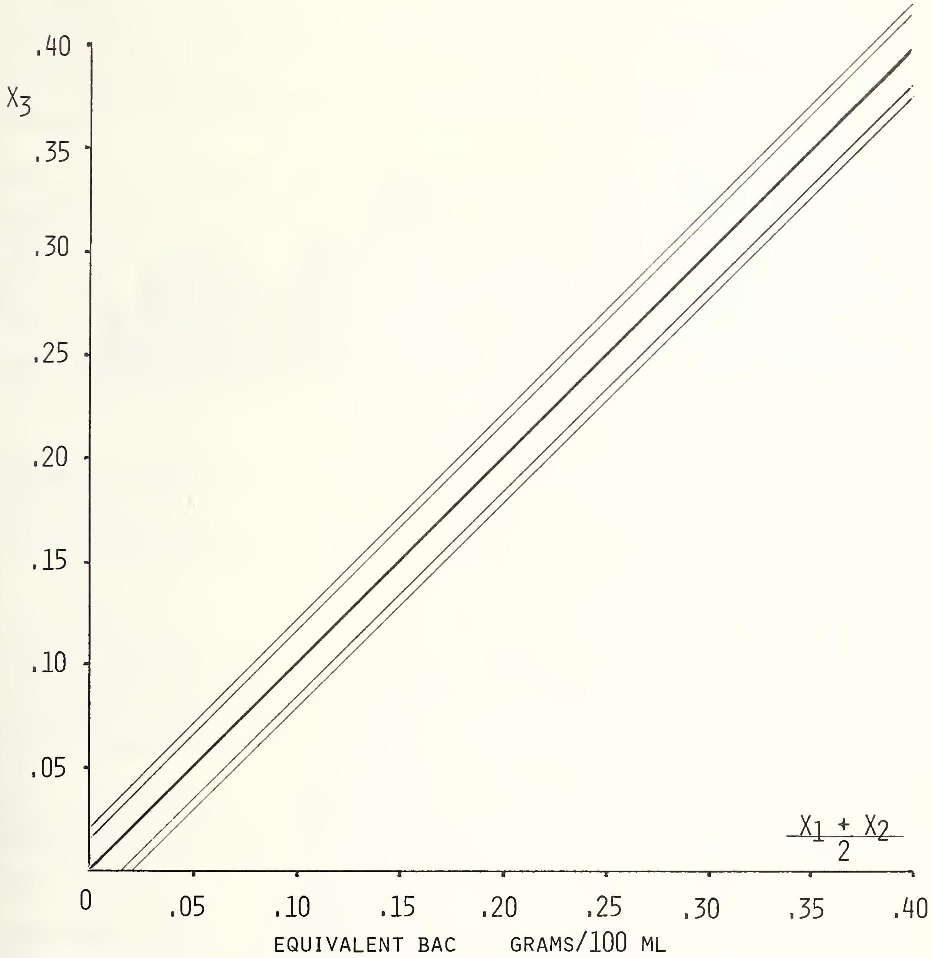


Figure 5 *Regression of* X_3 *on* $\frac{X_1+X_2}{2}$ *with 95% and 99% confidence limits. N = 2880, correlation coefficient = .998.* X_1 *= distal segment,* X_2 *= middle segment,* X_3 *= proximal segment.*

This greater scatter of the data may well represent a slight, gradual decay of ethanol concentrations in the encapsulated samples, or may be due to other, unknown factors. In any instance, such an error in operational precision in the method suggests that the system is on shaky ground when test results in the range .10-.13 are to be used for evidence in prosecution, particularly in Vermont where the law states that a portion of the test sample shall be retained for independent analysis for a period of up to 90 days. These calculations, of course, are solely concerned with the precision of the entire method as this is reflected in reproducibility and internal consistency. Thus, serious questions are posed when test results in the 0.10 g/100 ml range are to be transposed into court testimony.

DISCUSSION

This breath-testing system presents several advantages in a rural State with a widely dispersed drinking-driver population. The portability of the remote field collecting devices is a distinct improvement over methods which require testing in a fixed location, such as a State Police Outpost or station house. The existence of a single central testing facility greatly eases several problems in logistics and in the communication of test results. It has also been a great advantage to locate our testing facility in an academic setting, as we have done; this feature alone has greatly increased the credibility of the method to a jury.

This particular system does have disadvantages, some of which are noted above. Like other breath tests which attempt to sample alveolar air at end-expiration, we have encountered a persistent number of subjects who are physically incapable of deep exhalation because of chronic pulmonary disease. Another disadvantage concerns the initial attitudes of our police officers to the procedure. In earlier years, the officers had become accustomed to getting a breath test result within hours of the apprehension and testing of a suspect driver; with the present system, they are forced to wait for 3-4 days before they learn of the test result. Many officers are not comfortable with this arrangement, and they have communicated their displeasure to us.

Another disadvantage, incurred in the first year of our experience, is that which we have called the defective crimp error. The manufacturer has changed the template design, however, and as we have noted, the number of samples lost due to this mechanism has dropped to less than 1%. A persistent number of samples are still lost due to various other error sources, but this persistent loss rate is currently level at approximately 2% of the total.

Finally, there is the question of the precision of the overall method when subjected to statistical analysis of breath sample segments simultaneously collected. The presence of an error of ±13% at 95% confidence levels is disturbing indeed. In a jurisdiction which observes a statutory BAC of 0.10 g/100 ml it means essentially that BAC levels of less than 0.13 should be prosecuted with caution, and preferably along with other evidentiary material.

Our figures that indicate a decay process over 90-plus days of storage, resulting in an additional, significant loss of precision and reproducibility of the test results over time are relevant to those jurisdictions which also require the retention of an extra sample for independent analysis.

However, we have been moderately successful with this method particularly when compared to the ‘non-method’ which existed prior to its introduction.

Figures 6 and 7 present a precis of our two year experience. It must be remembered that Vermont is subject to fluctuations in traffic volume as it has a relatively small driving population but is inundated with tourists in late summer and autumn. This traffic volume is reflected in Figure 6.

Figure 7 shows BAC distribution for the drivers tested in our two-year collection. The incidence of drivers with zero alcohol by test (2.3%) is a reflection of those drivers stopped and tested because of a serious injury or fatal auto crash or because of other erratic driving behavior. The incidence of those drivers tested who were below 0.10 g/100 ml by test result is comparable, we think, to other experiences in other jurisdictions. The results in Figure 7 could be interpreted as an index of police selectivity in arrest and testing behavior. In this regard, we find it interesting that the number of persons thus selected for a breath test more than doubles in the interval between 0.07 and 0.09 g/100 ml. This observation lends support to those who argue

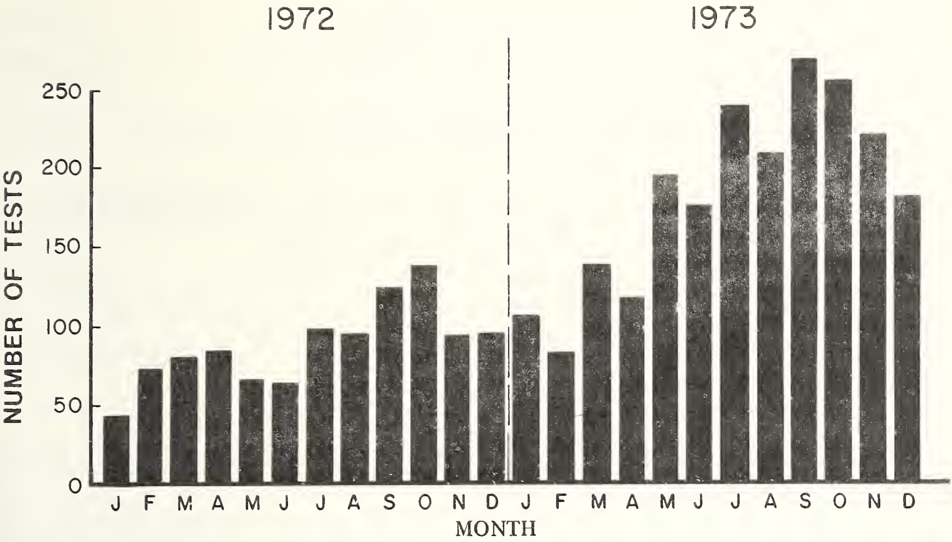


Figure 6 *Number of breath samples per month. Vermont: 1972-1973.*

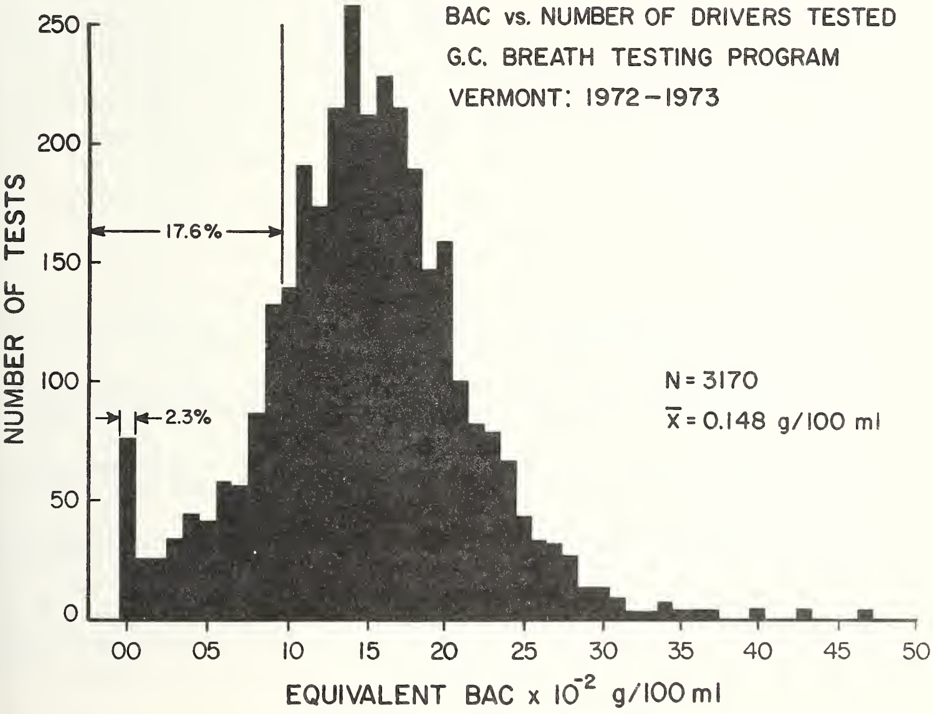


Figure 7 *Number of drivers tested by BAC.*

that a BAC of 0.10 g/100 ml is too conservative for use as a statutory, chemical definition of driving under the influence of alcohol.

TABLE II *Number of Prosecutions and DWI Convictions and BAC Results for 1970-71 and 1972-73*

Years	Total prosecuted	Convicted of DWI N	%	Average BAC (g/100 ml)
1970-71 Prior to program	1720	1359	79	0.215
1972-73 During program	4158	3271	77	0.147

Finally, Table II presents a summary of court behavior in our jurisdiction in the two years prior to the introduction of our new breath testing program, compared to the first two years of its application in courts of law. It can be seen that while the number of persons before the bar on charges of DWI has more than doubled in 1972-73, the conviction rate has remained essentially unchanged – at slightly less than 80%. The single striking finding, however, is that the average chemical test result has dropped from 0.215 g/100 ml to 0.147 g/100 ml. This suggests to us that our law officers are apprehending, arresting and testing out drinking-driving population with a greater awareness of the proper selection criteria and an appreciation of the gravity of the problem. At least we are sampling a little closer to the waterline of the iceberg, and the authors would like to think that the introduction of this breath testing program has contributed to this result.

REFERENCES

1. Hallett, R. A. *The Toronto Study.* The Centre for Forensic Sciences, Department of Justice, Ontario Province, Toronto, Canada, 1972.
2. Jones, A. W. and Jones, T. P., Breath Alcohol Analysis with the Intoximeter Gas Chromatograph. In *Proceedings OECD International Symposium on Countermeasures to Driver Behavior Under the Influence of Alcohol and Other Drugs,* 1971.
3. Morales, D. R., *Summary of Activities Relating to Evaluation of Instruments and Related Accessories for Breath Alcohol Analysis.* California State Department of Public Health, Berkeley, California, 1971.
4. Morris, R. L., Van Note, W., and Hausler, Jr., W. J. Chromatographic Breath Alcohol Test Program in Iowa, *Health Laboratory Science* 8, 142-149 (1971).

Practical Scientific Problems Associated with Drinking and Driving Legislation in England

Ann E. Robinson[1]

The Road Safety Act 1967 which became effective in October 1967 heralded a new era in the legal assessment of fitness to drive whilst affected by alcohol. The legislation introduced a scientific criterion – the blood (or urine) alcohol concentration – as the basis of an offence. Previously the necessarily subjective assessment of the driver's clinical condition, perhaps supported by a urine alcohol concentration, had been used and juries were often reluctant to convict unless the urine alcohol concentration was over 200 mg/100 ml.

Under the 1967 Act the motorist was to be found guilty if his blood alcohol concentration (BAC) was in excess of 80 mg/100 ml, the 'permitted level', at the time the blood sample was taken. The procedure was to include one or two breath tests using the Alcotest 80$^{(R)}$tubes, one at the roadside which, if positive, would result in arrest and conveyance to a police station. If a further breath test was positive the motorist would be asked to provide a blood sample and the police surgeon would be called. The time lapse between driving, the first positive breath test and the provision of the blood sample, therefore, varies from one case to another. In practice this varies from a few minutes, when the motorist is stopped close to a police station where the police surgeon is already in attendance, to a couple of hours. There is, however, no attempt or need to correlate the BAC at the time of the alleged offence with that at the time the blood was taken. If the motorist opts to provide a urine specimen rather than blood, he is guilty of an offence under the Act if the alcohol concentration in the second of two urine specimens provided within an hour exceeds the permitted level of 107 mg/100 ml. This concentration is derived from a BAC of 80 mg/100 ml multiplied by the 'average' blood/urine ratio.

The definition of an offence in scientific terms should have resulted in the removal of some of the anomalies and injustices perpetrated in the past. Unfortunately the variations between the police surgeons with regard to clinical judgment were substituted, at least initially, by arguments over scientific details. In my view, many of the initial difficulties could have been avoided. When the law became effective, because of a lack of foresight, there was neither evaluation of the containers that were used nor any data pertaining to the influence of conditions of the storage of specimens before analysis. It does not seem unreasonable to expect that these vital factors should have been assessed when a criminal conviction will result if the offence is proved. After all, a pharmaceutical house does not introduce a new preparation on the market without first checking its stability under various storage conditions.

---

[1] Department of Forensic Medicine, The London Hospital Medical College, Turner Street, London E1 2AD, England.

I do not propose to detail the early scientific problems that occurred as these have already been discussed (2). Rather, I shall reconsider the persistent problems and the current position.

BLOOD SAMPLES

A gas chromatographic method of analysis of the small volume blood samples has been used in most laboratories and has proved most satisfactory. From the introduction of the Road Safety Act, the blood samples were presented in small polypropylene pots having close fitting, snap-on lids. The capacity of these containers was 300 μl and they were already coated with a dried film of anticoagulant and preservative chemicals sent out for use by the police surgeons. When no other anticoagulant was used, for example in the syringe, and unless the blood was rapidly and effectively mixed with that in the container, a clotted sample resulted. These containers are still in use in some parts of the country but since a 5.6% failure rate as containers has been demonstrated (1), they will presumably be replaced. Glass vials are now being provided in the area served by the Metropolitan Police Laboratory.

A persistent problem with the original plastic container was the occurrence of clotted blood samples. Analysis of portions of a partially clotted specimen often gave variable results. Also, the defence or independent analysts, having a single specimen for analysis, might unwittingly remove part of a sample before appreciating that the blood was clotted. The composition of the remaining volume would then not be equivalent to the original specimen since plasma contains proportionately more alcohol than the blood cells.

The clotting process is irreversible but it has been suggested that dispersal of the clot(s) into particles small enough not to block the sampling devices and syringes is sufficient to allow a proper analysis. Whether the homogenised specimen may properly be regarded as 'blood' for the purposes of the Act might well be debated. Even the use of a small plastic sieve device of the specification used in the Home Office Forensic Science Laboratories does not always allow the effective dispersal of a clot. Other suggested methods are either ineffectual or result in partial or extensive haemolysis. There have been widely differing estimates of the proportion of blood samples submitted for analysis that are said to be clotted. This varies according to the criterion used: the presence of small clots visible to the naked eye may constitute a clotted sample to one analyst while another only considers the sample to be clotted when the sampling device becomes obstructed by the specimen. Hence during one six week period studied, Rudram (3) noted that less than 1% of specimens received were recorded as clotted whereas our own experience during the same period of time in the same area of the country showed 74% of the blood samples to be at least partially clotted on visual inspection.

Since the introduction of larger volume glass containers, no clotted blood sample has been submitted to me for analysis. Indeed most of the specimens have been partially or completely haemolysed on receipt.

The new containers consist of 5 ml capacity glass vial with a vaccine bottle type of closure. When sent out for use by police surgeons they contain anticoagulant/preservative and 2 glass beads. The blood sample is put in by syringe through the self re-sealing septum and shaken. The vial with label is then enclosed in a translucent pot, the lid of which can only be removed when a 'tear-off' strip has been detached. The whole is then put into a special envelope which has instructions to the driver and the analyst printed upon it.

Storage of Blood Samples

It is clearly impossible to analyse all blood samples within a few minutes or even a few hours after collection. Some, though not all, drivers await the result of the prosecution analysis before seeking an independent analysis or taking legal advice. Thus there may be a greater delay before the specimen reaches the independent analyst than obtains for the police specimen though this is by no means always so (Table I).

TABLE I *Time Interval between Collection of Blood and Urine Specimens and their Analysis*[a]

Time interval	1970	1971	1972	1973	1974[b]
	Percentage of specimens				
Same day	2.8	1.8	2.6	0.6	6.2
Up to 7 days	64	64.3	63.5	63	67.7
8 to 14 days	12.7	15.5	21.1	21.8	12.3
15 to 21 days	2	4.2	3.2	2.6	1.5
Over 21 days	18.3	14.3	9.6	11.9	12.3
TOTAL	100	100	100	100	100

[a] Collected under the Provisions of the Road Safety and Road Traffic Acts. Analyzed at London Hospital Medical College.
[b] First six months.

Two factors then require consideration: whether the container is satisfactorily closed to prevent loss of alcohol; and whether the alcohol is stable in the blood sample.

Practical experience with the small plastic pots indicated that though some, perhaps, most, samples analysed several weeks after collection gave results lower than those reported by the prosecution, there were some samples which gave comparable results even after prolonged storage intervals of 4 or 5 months. Bacteriological examination of such samples has always shown them to be free from contamination by fermenting organisms. Confirmation that some of the containers were indeed unsatisfactory was not published until September 1973 when they had been in use for nearly six years. In these circumstances there can be no justification for quoting or predicting the rate of loss of alcohol from these containers.

Studies by Brown *et al* (1) and Smalldon and Brown (5) on the stability of ethanol in stored outdated transfusion blood demonstrated that oxidation to acetaldehyde occurred at 62°C. The authors speculated that losses of ethanol from blood at other temperatures were due also to oxidation. While it is not unreasonable to anticipate oxidative degradation, these workers did not present definitive evidence that loss of alcohol from drinking drivers' blood samples mixed with oxalate and fluoride and stored in the polypropylene pots was necessarily due to oxidation. Indeed, since not all such specimens lose alcohol on storage, leakage from the container appears a more likely explanation.

Smalldon (4) has since reported that the alcohol content of 'a normal blood sample' may be stabilised by the addition of azide, bisulphite, dithionite or nitrite, as the sodium salt. Presumably one of these substances will be included with the anticoagulant and fluoride in the containers supplied for use by police surgeons at some future date.

The 5 ml capacity glass vials have been in use for only a few months and it is to be hoped that they will prove to be more satisfactory than the plastic containers they replace. At the present time, however, the failure rate does not seem to be known; I have already encountered one case in which there was a considerable loss of alcohol in the defendant's sample after 5 weeks' storage. There is the further potential risk that some alcohol might be lost through the punctured septum particularly if several attempts are needed to insert the blood into the vial.

URINE

A brief discussion of urine specimens provided under the provision of the Road Traffic Act is also relevant. Firstly there appears to be some confusion about the 'two specimens within an hour'. This wording was presumably formulated by lawyers following the advice of a British Medical Association Committee (6) that two specimens should be collected, the second about a half hour after the first. The first specimen provides an opportunity for the bladder to be emptied so that the second specimen will comprise urine secreted into the bladder within the time interval. This would then contain alcohol in proportion to that currently circulating in the blood. The average urine: blood alcohol ratio on a falling blood alcohol level was taken as 1.33:1 and this figure was used in the calculation of the permitted urine alcohol concentration. Therefore, unless the bladder is first emptied, the urine alcohol concentration may not reflect the blood alcohol concentration.

One of the problems regarding urine specimens arises from the interpretation of the requirement of 'two specimens within an hour'.

In one case in which I was concerned, a driver was being prosecuted on the basis of a urine alcohol concentration only slightly in excess of the permitted level. The police officer had noticed that he was finding difficulty providing the first specimen and advised him to "go easy Guv, I'll need another in a minute". The second specimen may in consequence have had a higher alcohol content and though guilty of an offence under the Act the motorist was not disqualified from driving.

Few persons concerned with the practical enforcement and the provisions of the Act with regard to urine specimens appear to understand the reason for the collection of 2 specimens, the first of which is to be rejected. On several occasions in my experience this has resulted in the time interval being only a matter of a few minutes which may be to the driver's disadvantage particularly if he is near the 'limit'. It should be remembered also that the rate of secretion of urine is apprixmately 1 ml per minute.

The second problem relating to urine specimens is again that of the containers provided. Loss of alcohol from the screw-capped glass bottles may or may not occur and the rate of loss when it does occur is unpredictable. Screw-capped plastic tubes are used in some parts of the country but not all are satisfactory, for example leakage round the screw thread has been noted on many occasions and such leakage is not prevented by wrapping transparent tape round the lower edge of the cap.

BREATH TEST

Another aspect which deserves some attention relates to the breath test. In most instances two positive breath tests using Alcotest 80 tubes are given by the motorist before a blood or urine sample is provided. Analysis of results for a significant proportion of specimens subsequently show less than the permitted level of alcohol. At least half of those results that are recorded as under '80' are in fact under 60 mg/100 ml (Table II).

TABLE II *Independent Analytical Results for Drinking Drivers' Blood Samples*

BAC in mg/100 ml	1970	1971	1972	1973	1974[a]
	Percentage of samples				
< 80	24.4	34.5	29.1	24.5	18
81 to 100	16.8	12.4	9.9	14	21.3
100 to 160	31.3	30.3	32.5	36.4	27.9
> 160	27.5	22.8	28.5	25.2	32.8
TOTAL	100	100	100	100	100

[a] First six months.

Although the breath test is used only as a preliminary screening device, it might be appropriate to consider the manner of interpretation of the tubes by those concerned. This assumes that the breath test has been performed in accordance with the manufacturer's instructions, *i.e.*, that one puff not several has been used and that the bag does not have a hole in it. I find it disturbing that some blood samples, which are mostly taken within an hour of a positive breath test, are found to contain much less than 80 mg alcohol/100 ml on subsequent analysis.

I would not wish to leave the impression that the practical scientific problems remaining in connection with the British legislation are insuperable. Our own data for the independent analysis of the accused person's blood or urine specimens show that the largest proportion are presented for analysis within seven days of collection and much smaller numbers after two weeks. Most specimens are still 'sealed' on receipt though even the printed advice to present the sealed specimens to the analyst may not be heeded by medical or legal advisers. Most of our results are in agreement with those obtained by the prosecution analysts. The greatest current concern, therefore, relates to the container from which alcohol must not be lost during a brief storage period under reasonable conditions.

REFERENCES

1. Brown, G. A., Neyland, D., Reynolds, W. J. and Smalldon, K. W., The Stability of Ethanol in Stored Blood. Part I. Important Variables and Interpretation of Results, *Analytica Chimica Acta* 66, 271-283 (1973).
2. Robinson, A. E. and Camps, F. E., Scientific Problems Associated with the Road Safety Act 1967, *Medicine Science and the Law* 10, 69-75 (1970).
3. Rudram, D. A., The Incidence of Clotted Blood Samples in Road Safety Act Cases, *Journal of the Forensic Science Society* 14, 19 (1974).
4. Smalldon, K. W., Ethanol Oxidation by Human Erythrocytes, *Nature, London* 245, 266-267 (1973).
5. Smalldon, K. W., Brown, G. A., The Stability of Ethanol in Stored Blood. Part II. The Mechanism of Ethanol Oxidation, *Analytica Chimica Acta* 66, 285-290 (1973).
6. *The Drinking Driver: Report of a Special Committee of the British Medical Association*, BMA, London, 1965.

Alcohol Concentration in Urine and Its Forensic Evidence

Peter Zink[1] and Günther Reinhardt

The first experiments regarding the relationship between alcohol concentration in blood and urine were performed by Widmark in 1930. Since then there have been many experiments performed all over the world. In the last few years, using human subjects, we have conducted research on (a) the trend of ureteral urine alcohol concentration, (b) the relationship between ureteral urine-, vesical urine- and blood alcohol, (c) the equilibrium between blood, serum and urine by constant blood alcohol concentration and (d) the permeability of the bladder for alcohol.

OBSERVATIONS

Because of physiological conditions, the urine alcohol concentration depends upon the following: (a) quantity of blood alcohol concentration, (b) amount of alcohol concentration in the ureteral urine, (c) diuresis, (d) time between the mictions, and (e) permeability of the bladder for alcohol.

We have found that the rising ureteral urine alcohol curvature follows the blood alcohol and serum alcohol curve by about 10 minutes. We obtained the result from a patient with an ileal conduit. The same results were obtained from subjects who provided urine samples every 10 minutes. A comparison between the concentration of bladder excretion and ureteral excretion gave almost identical results when bladder samples were taken at short intervals.

With longer periods between mictions, for example up to one hour, the quotient alcohol in urine to alcohol in blood was low (0.5 - 1) in the initial stages after drinking; when the maximal stage was past, a quotient of 1.3 - 1.4 was obtained. When the blood alcohol concentration fell to values less than 30 mg/100 ml the quotient could increase to more than 2. From these experiments we found that the vesical alcohol concentration compared to the blood alcohol concentration curve reflected a difference of half an hour. After drinking 2 liters of tea this period was shortened to 15 minutes.

In other experiments it has been shown by direct insertion of alcohol in the bladder (concentration 1 - 2 ^{0}/oo), that the bladder walls do not let an appreciable amount of alcohol pass through. When the concentration in the bladder was 1 ^{0}/oo and the blood was free of alcohol we found a diminution of the amount of alcohol in the bladder of about 10 mg in the first hour. Similar results were found by Haggard, Greenberg, Carroll and Miller (4).

---

[1] Institut für Rechtsmedizin, D 8520 Erlangen, Universitätsstr. 22, West-Germany.

Experiments on diffusion have shown that the equilibrium concentration between serum and urine was 1 : 1.07 depending on the amount of protein in the serum. The same results were obtained by direct injection of alcohol into the blood stream of a human subject so that a constant blood alcohol concentration was reached. During this time, the subject gave urine samples at short intervals. The exact details of our experiments and the data involved are available elsewhere (8, 9, 10).

DISCUSSION

The experimental relationship between urine and blood alcohol concentration can be explained by diffusion of the alcohol in the kidney without active cell performance. The change of alcohol concentration in the bladder and ureter is influenced by the periods between mictions. The longer these periods the more likely there will be differences between ureteral urine and vesical urine alcohol, in that the liquid that enters the bladder from the kidneys changes its alcohol concentration.

The concentration of vesical urine is determined by diuresis. The permeability of the human bladder for ethyl alcohol has no effect on the alcohol concentration in vesical urine, even after the urine has settled over a period of several hours in the bladder.

In the maximum stages, and in the downslope of the blood alcohol curve, the vesical urine alcohol concentration by frequent miction periods is about 1.3 - 1.4 times higher than blood alcohol concentration (2, 5, 6, 7). After the first amount of alcohol has been consumed, the vesical as well as the ureteral urine alcohol concentration is less than the blood alcohol concentration of the cubital vein blood. It must not be assumed that this is caused by dilution of the first ureteral urine containing alcohol by residual urine in the bladder. The time delay can be explained by the time it takes for the kidney cells to absorb the alcohol from the blood and give it off as urine.

Even under laboratory test conditions, the variation of the quotient urine alcohol concentration/blood alcohol concentration is very high. Under practical conditions even after two urine samples have been taken, it is impossible to determine the true blood alcohol concentration from the result of the determination of alcohol concentration in the urine samples. The statistical relationship between blood and urine alcohol concentration, as determined by Froentjes and Verburgt (3) and Bonnichsen and Aberg (1), lowers the margin of error.

The phase of the blood alcohol curve can be better determined, if a blood sample and a urine sample taken at the same time, are compared. In spite of this, it is still not reliable proof or evidence of the blood alcohol phase.

The difficulties in the evaluation of urine samples in forensic cases are that the amount of alcohol consumed, the time factor of drinking, the last miction, the residual urine in the bladder and the diuresis are unknown.

REFERENCES

1. Bonnichsen, R., Aberg, C. J., Alcohol in Blood and Urine *Acta medicinal legaliset socialis* 16, 65 (1963).

2. Elbel, H., Schleyer, F., *Blutalkohol*, 2. Aufl., Stuttgart, Thieme, 1956.
3. Froentjes, W., Verburgt, J. W., Über die Ermittlung des Alkoholgehaltes im Blut aus der Urinalkoholkonzentration in gerichtlichen Fällen. *Blutalkohol* 3, 476 (1966).
4. Haggard, H. W., Greenberg, L. A., Carroll, R. P., Miller, D. P., The Use of the Urine in the Chemical Test for Intoxication. Possible errors and their avoidance. *Journal of the American Medical Association* 115, 1680 (1940).
5. Heise, H. A., Concentrations of Alcohol in Samples of Blood and Urine taken at the Same Time. *Journal of Forensic Science* 12, 454 (1967).
6. Lundquist, F., The Urinary Excretion of Ethanol by Man. *Acta pharmacologica et toxicologica* 18, 231 (1961).
7. Rupp, W., Raudonat, H. W., Muschaweck, R., Hajdu, P., Brettel, H. F., Die Bedeutung der Diurese bei Trinkversuchen. Einfluß auf die renale Ausscheidung von Alkohol und Flüssigkeit. *Blutalkohol* 6, 325, (1969).
8. Weinig, E., Zink, P., Reinhardt, G., Über die forensische Bedeutung der Alkoholkonzentration im Urin. *Blutalkohol* 7, 307 (1970).
9. Weinig, E., Zink, P., Reinhardt, G., Die Durchlässigkeit der menschlichen Harnblase für Athylalkohol. *Journal of Legal Medicine* 67, 147 (1970).
10. Zink, P., Reinhardt, G., Zur Theorie der Äthanolausscheidung im menschlichen Urin, *Blutalkohol* 8, 1 (1971).

The Hamburg, W. Germany, 1973 Report Questioning the Reliability of Breath Alcohol Instruments for Medicolegal Use in Traffic Cases

Rolla N. Harger[1]

In the Hamburg area of W. Germany, and apparently in the entire nation, the only chemical test evidence accepted by the courts in traffic cases is that from the analysis of blood, which is drawn exclusively from the cubital (elbow) vein.

Around 1970, a Hamburg physician issued a statement proposing an extensive study using arrested drinking-drivers in which Breathalyzer readings would be compared with results of analysis of blood. This proposal was strongly criticized by v. Below, a Hamburg attorney (39), on the ground that breath alcohol analyses cannot be legally used in W. Germany. As a result of this argument, and further public interest in replacing blood alcohol analyses with breath analyses, and since the latter would save much time and avoid puncturing the body to draw blood samples, the Hamburg senate created a commission to investigate the reliability and legality of breath alcohol instruments.

Following what appears to have been a rather cursory investigation, this commission issued a report, dated April 26, 1973. It is a 15-page document, in German (25). Our rather free translation of the title of the report reads: "The Reliability of Methods of Breath Alcohol Analysis for Estimating the Blood Alcohol Concentration in Forensic Cases".

Although the authors of the report, J. Lamprecht, a senate director, and K. Leuschner, a senate counsel, are not scientists, the text of the report indicates that the data presented in it were furnished by certain members of the staff of the Hamburg Institute of Forensic Medicine, who have conducted studies on the pharmacology of alcohol, and who are apparently the authors of the conclusions reached by the commission.

An English summary of this Hamburg report appeared in the International Comments section of the November 26, 1973 issue of the Journal of the American Medical Association, and is headed, "Breath Alcohol Testing Cannot Replace Blood Alcohol Determination" (2). The anonymous author of this summary evidently did not consult the AMA Committee on Medicolegal Problems (1) regarding the numerous published blood-breath correlation studies with at least a dozen breath alcohol instruments which preceded this Hamburg report, and he is apparently convinced that the Hamburg pronouncements sound the death knell of breath alcohol analyses.

---

[1] Professor Emeritus of Biochemistry and Toxicology Indiana University School of Medicine, Indianapolis, Indiana, U.S.A.

BREATH ALCOHOL INSTRUMENTS AND DEVICES CONSIDERED BY THE COMMISSION

The scientific evidence on breath alcohol analytical procedures which was considered by the commission is presented in two sections. The first discusses the new Alcotest screening device, and the second deals briefly with three quantitative breath alcohol instruments.

New Alcotest Screening Detector Tubes

This section describes the results of a study of a new model of the Grosskopf Alcotest detector tube in which the yellow H_2SO_4-chromic acid section is divided into five subsections, separated by short sections of the white, supporting silica gel. Performance studies with the earlier Alcotest detector tubes have been reviewed by Harger and Forney (17, 18), and a 1968 paper by Day *et al.* (10) reported a further study with the earlier Alcotest detector tubes.

A supply of the new model Alcotest detector tubes and the suction pump which draws a fixed volume of the subject's breath through the tube were furnished to the Hamburg police department by the manufacturer, Draeger Co. of nearby Lubeck, W. Germany. Under the supervision of the Hamburg Institute of Forensic Medicine, Hamburg police technicians tested the breath of arrested drinking-drivers with these new Draeger detector tubes, and blood samples from the subjects were analyzed for alcohol content. The correlation results were very disappointing, and the new model Alcotest tubes were rejected for use by the Hamburg police. The commission report makes no mention of the 1968 study by Day (10), or of any earlier studies.

Three Quantitative Breath Alcohol Instruments

Breathalyzer and Ethanographe. The Ethanographe is manufactured by Etzlinger of Switzerland, and is also called the Alcolinger Automatic. The Hamburg report states, "The Ethanographe is a simplified and technically much improved modification of the Breathalyzer". However, the report adds that both instruments have the same defect as the Widmark blood alcohol method, namely, the determination of ethanol by the well-known dichromate-H_2SO_4 reagent. Since this reagent is not absolutely specific for ethanol, the commission arbitrarily rejected both instruments for use in W. Germany, where the traffic authorities had earlier banned the Widmark blood alcohol method for this reason.

Reliability of the G-C Intoximeter. The remainder of this 7-page section is devoted to the G-C Intoximeter, including a description of the instrument and a summary of the results of two performance studies of it made by certain staff members of the Hamburg Institute of Forensic Medicine. The report devotes only a few sentences to the procedures and results of these two studies, so I will summarize them more fully.

(a) The 1972 Report of Schmutte, Naeve, Wilhelmi and Brinkmann (34): A 1971 model of the G-C Intoximeter was presented by the manufacturer to the Hamburg Institute of Forensic Medicine for this study. During a period of one hour, 18 subjects ingested alcohol beverages to give blood alcohol concentration (BAC) peak levels of 70 mg/100 ml to 200 mg/100 ml. At ten intervals during 130 minutes after the end of drinking, the subject's breath was tested with the G-C Intoximeter and blood was simultaneously drawn from the cubital vein for analysis by the Machata

G-C, headspace procedure (26). The paper does not give the raw data for all of these analyses, but does give a peculiar scatter diagram showing the percent deviation between breath and blood values for the 18 blood-breath pairs taken at each of the ten time intervals following the end of drinking (Figure 1).

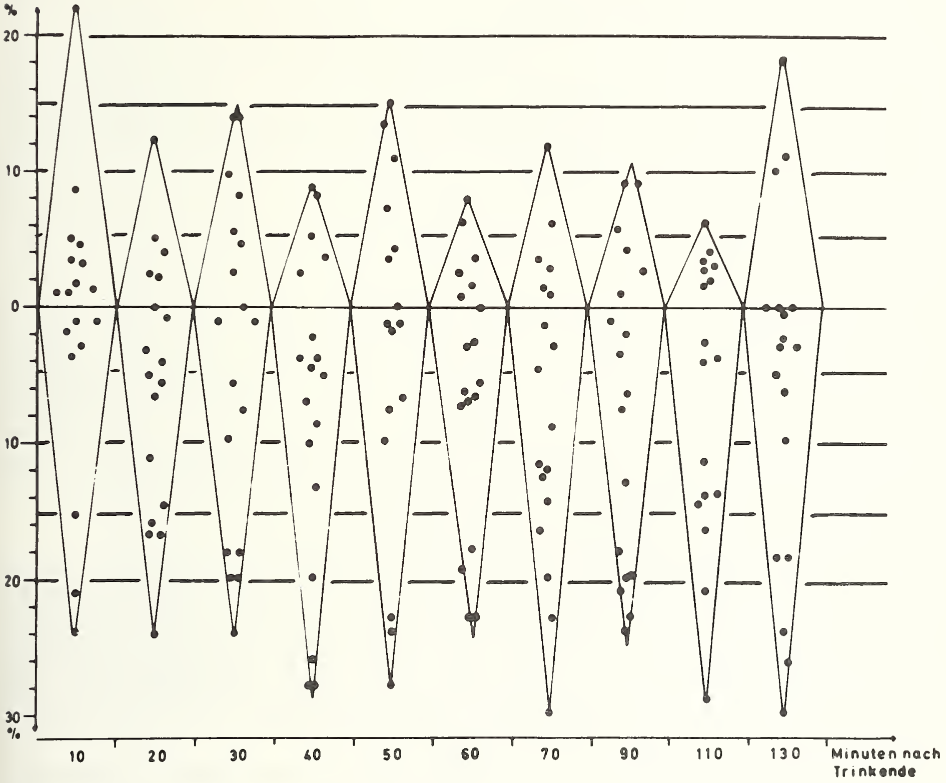


Figure 1 *A type of scatter diagram showing the per cent deviation of G-C Intoximeter readings from cubital vein BAC of 18 drinking subjects at 10 intervals after a 1-hour drinking period. The BAC peaks ranged from 70 to 200 mg/100 ml. The ordinate scale is in % deviation, with breath > blood above the zero line and the reverse below. Each double triangle encloses all data for that time interval. Abscissa scale, minutes after end of drinking. The ordinate scale magnifies the degree of deviation. Eight horizontal lines have been drawn parallel to the zero line to facilitate estimating the data which are presented as study 24 in Table I. From Schmutte et al. (34).*

While the ordinate scale in this graph magnifies the per cent deviations of G-C Intoximeter readings from the corresponding BAC values, it will be seen that at 10 minutes after the end of drinking, the deviations with 14 of the 18 blood-breath pairs were within ±5%, with an average of about +2%, which average decreased to about –8% during the last four test periods. The greatest per cent deviation of breath from blood occurred at 130 minutes after the end of drinking and was about –30%. For four of the subjects, the authors gave the complete blood-breath data as curves, which they call "characteristic" (Figure 2).

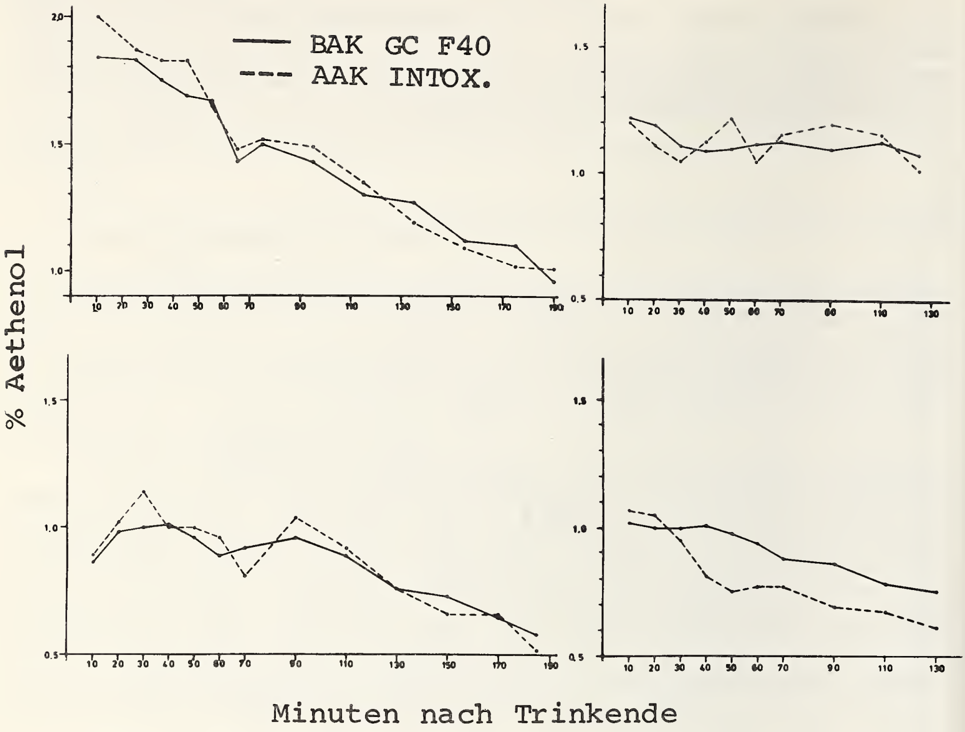


Figure 2 *Curves showing G-C Intoximeter readings and cubital vein BAC for 4 of the 18 subjects tested by Schmutte et al. (34). These have been assembled in one figure for comparison. Ordinate scale, $^o/oo$ (mg/ml) BAC; to translate to mg/100 ml, multiply by 100. Abscissa scale, minute after end of drinking. Note that the X axis, if given, would be much below the horizontal lines in the graphs. Heavy lines, cubital vein BAC; dotted lines, G-C Intoximeter readings. The authors term these curves "characteristic". These data, translated to percentage deviations between breath and blood, are included in Figure 1. From Schmutte et al. (34).*

If these four pairs of curves are compared with the X axis, which is not shown, it will be seen that, for three of the subjects, the blood-breath correlation is really quite satisfactory. With three of the subjects, there was a tendency for the breath values to exceed the BAC for 20 to 40 minutes after the end of drinking. This phenomenon is discussed below. Even with the pair of curves in the lower right graph, the breath-blood deviation is fairly uniform, averaging about –16% during the period of 40 to 130 minutes after the end of drinking.

(b) The 1973 Report of Schmutte, Stromeyer and Naeve (35): This is a continuation of the above-mentioned study reported by Schmutte *et al.* in 1972. The chief purpose of the 1973 investigation was to test the effect of a minute or two of vigorous exercise and, or, hyperventilation, on the G-C Intoximeter reading and the BAC of drinking subjects. The study employed 27 subjects, the drinking time was 1, 2 or 4 hours, and the maximum BAC did not exceed 190 mg/100 ml. At 12 time intervals, beginning 10 minutes and ending about 200 minutes after the end of drinking, the subject, while resting, was given a G-C Intoximeter test and a sample of cubital vein blood was taken. Shortly afterwards he underwent a brief period of physical exercise and, or, hyperventilation, and breath and blood samples were immediately taken for analysis.

Physical exercise + hyperventilation caused a drop of up to 20 mg/100 ml in the G-C Intoximeter readings, and hyperventilation alone caused an average decrease of about 6 mg/100 ml in the breath readings. In 1965, Monnier reported a similar fall in breath alcohol after vigorous exercise (27). These results are obviously of little importance in practical breath testing of arrested drivers.

The data for the resting phase show a fair correlation between the breath and blood values, with the average G-C Intoximeter reading about 16 mg/100 ml below the BAC.

The authors felt that the breath-blood deviations observed were not due to instrumental deficiency of the G-C Intoximeter, but to inherent variations in the blood-breath ratio.

CONCLUSIONS OF THE COMMISSION REGARDING QUANTITATIVE BREATH ALCOHOL INSTRUMENTS

These pronouncements of the commission are evidently the conclusions of the staff members of the Hamburg Institute of Forensic Medicine who made the two studies with the G-C Intoximeter.

1. The chief objection of the commission to the use of breath analyses in W. German traffic cases is that, during the period of rising BAC, the breath instrument reading is frequently much above the BAC in the cubital vein. The reason for this discrepancy was apparently known to the Forensic Institute scientists, because the reports states (our translation):

> *The chief physiological cause for the lack of agreement between the breath alcohol and blood alcohol readings during the absorption phase is that the alcohol concentration in the blood of the lungs, which controls the concentration of alcohol in the alveolar air, is higher than the alcohol concentration of venous blood in the extremities, which are the officially prescribed sources for blood sampling (by the police physician).*

Therefore, under existing W. German regulations, the commission held that the accused driver should have the benefit of the lower BAC of cubital vein blood.

2. While the commission would apparently accept a maximum divergence of ± 10% between the breath instrument reading and the result of direct blood analysis, in the 1972 study of the G-C Intoximeter by Schmutte *et al.* (34) this requirement was met by only about two-thirds of the blood-breath pairs. However, an examination of Figure 1 will show that, of the 180 blood-breath pairs analyzed by Schmutte *et al.*, there were only 10 pairs wherythe G-C Intoximeter reading exceeded the BAC by more than 10%. About one-fourth of the pairs did have negative deviations exceeding −10%, but according to the reasoning in objection No. 1, such negative deviations should be accepted.

3. While blood samples may be stored for months without alteration of alcohol content, this cannot be done with breath.

4. Under W. German law, blood samples may be taken from the accused driver without his consent, but there is no provision for compulsory breath sampling.

5. Proper analysis of breath requires active cooperation of the subject, and with comatose subjects breath analysis is impossible.

6. Conventional, quantitative breath alcohol instruments are too expensive, cumbersome and fragile to be routinely carried in a police car.

7. There appear to be no scientific grounds for recommending that breath alcohol procedures should replace the official blood alcohol testing program, or even be used for screening purposes.

COMMENTS ON THE CONCLUSIONS AND PRONOUNCEMENTS OF THE HAMBURG COMMISSION

The scientific evidence presented to the Hamburg commission involves just one breath alcohol instrument, namely the 1971 model of the G-C Intoximeter. At least six other quantitative breath alcohol instruments were available in 1972, most of which had been used for evidential purposes for years. A search of the literature would have revealed a large number of blood-breath correlation studies with several of these instruments. On this matter, see reviews by Harger and Forney (17, 18). In Table I, the results of 27 such blood-breath correlations, which have been published during the past 20 years, and which involve nine quantitative breath alcohol instruments, are summarized. We will discuss some of these studies in the following paragraphs where some of the conclusions and pronouncements of the Hamburg commission are considered in more detail.

TABLE I *Blood/Breath Alcohol Correlations Conducted by Various Investigators with Nine Quantitative Breath Alcohol Instruments*[a]

			ACCURACY OF BLOOD-BREATH CORRELATION				
			Percentage of cases within			Fraction	Arith. mean of
Study Number	Date	Instrument and Investigator(s)	±5%	±10%	±15%	beyond ±15%	Br/Bl. deviation
1	1956	Drunkometer; Reb. Air Harger et al (20)	54	87	98	2	1.3%
2	1957	Breathalyzer Chastain et al. (8)	38	62	91	9	–6.7%
3	1957	Alcometer Chastain et al (8)	53	78	95	5	–1.3%
4	1959	Breathalyzer Coldwell & Smith (9)	30	51	68	32	–10%
5	1959	Breathalyzer Fennell (11)	40	68	84	16	–6.1%
6	1960	Breathalyzer Bayley et al. (3)	26	52	72	28	–8.5%
7	1963	Breathalyzer Scroggie (36)	Results given in mg/100 ml only:				
8	1964	Breathalyzer Begg et al. (4)	5	17	38	62	–17.5%[b]
9	1964	Kitagawa-Wright, Hermes Begg et al. (4)	31	49	68	32	–1.9%[b]
10	1964	Drunkometer; Reb. Air[c] Forney et al. (12)	64	86	93	7	–4.0%
11	1969	Breathalyzer; w. blood Franklin (14)	33	59	87	13	–9.7%
12	1969	Breathalyzer; Plasma Franklin (14)	28	59	76	24	–9.9%
13	1969	Breathalyzer Shupe & Pfau (37)	42	61	84	16	–0.3%
14	1969	G.C. Alco Analyzer Shupe & Pfau (37)	60	70	75	25	–4.9%
15	1969	Alco Tector Shupe & Pfau (37)	51	78	88	12	1.7%

TABLE I continued

16	1969	G.C. Intoximeter Penton & Forrester(32)	58	61	73	27	−4.3%
17	1969	Breathalyzer Harger & Forney (19)	25	61	80	20	−7.1%
18	1969	Breathalyzer; Reb. Air[d] Harger & Forney (19)	57	74	92	8	−2.2%
19	1970	Alcolinger Automatic Bonte et al. (5)	45	66	85	15	+3.6%
20	1971	Intoxilyzer; 12 tests only; +2% to −11% Harte (22)					−3.2%
21	1971	Breathalyzer Prouty & O'Neill (33)	25	57	74	26	−5.2%
22	1972	Breathalyzer Morales (28)	31	58	82	18	−0.7%
23	1972	G-C Alco Analyzer Morales (28)	15	31	66	34	−13.7%[e]
24	1972	G-C Intoximeter Schmutte et al. (34)	45	65	82	23	−4.4%[e]
25	1973	G-C Intoximeter					
		a. Direct analysis	15	63	77	23	−10.2%
		b. Indium capsules	61	79	97	3	+ 1.8%
		Hoday (23)					
26	1974	G-C Intoximeter Morales (28)	34	82	90	9	−6.6%[e]
27	1974	Intoxilyzer Morales (28)	28	65	86	14	−10%[e]

[a] Adjusted to employ the 2100/1 ratio for blood/alveolar air, or blood/rebreathed air.

[b] In studies 8 and 9, BAC values below 50 mg% are omitted.

[c] Arterial blood.

[d] These tests followed the preceding tests almost immediately, using the same Breathalyzer and subjects.

[e] Correlation values in the five columns were estimated from a scatter diagram in the authors' paper, or report.

Lag in BAC of Cubital Vein Blood During Rising BAC

While the commission report acknowledges this phenomenon and admits that the readings of a breath alcohol instrument will usually exceed the venous BAC during active absorption, the authors should have added that the arterial BAC controls the alcohol concentration of the brain and, therefore, the degree of intoxication. From this, it follows that, during rising BAC, alveolar or rebreathed air, is far more reliable than cubital vein blood for diagnosing intoxication. In the 1972 paper by Schmutte *et al* (34), quoted by the commission, the bibliography contains a reference to a 1963 paper by Harger (16) with the title, "Blood Source and Alcohol Level; Errors From Using Venous Blood During Active Absorption", but the commission report does not acknowledge such errors in W. Germany.

That erroneously low cubital vein BAC values during rising BAC almost certainly occur in traffic cases in W. Germany, is amply confirmed by the results of four studies (6, 7, 29, 31) published by investigators of the group which conducted the performance tests with the G-C Intoximeter described above.

The following is an example of one of these studies (7): Eighteen subjects were used who ingested about 1.15 gm of alcohol per kg of body weight during a period of

20 minutes. Cubital vein blood samples were taken just prior to, and just after, the drinking period, and at 10-minute intervals ending at 100 minutes after the end of drinking. At each test period, the subject was examined for symptoms of intoxication by two experienced police physicians. The venous BAC values and the clinical diagnosis for each of the 18 subjects obtained immediately after the end of the drinking period, and at the BAC peak, are given in Table II.

TABLE II *Cubital Vein BAC and Degree of Intoxication, Following Rather Rapid Drinking*[a] [b]

Subject Number	Ten minutes after end of drinking		At time of blood alcohol peak	
	BAC in mg/100 ml	Degree of intoxication	BAC in mg/100 ml	Degree of intoxication
1	15	Mild intox.	170	Mild intox.
2	30	Frank intox.	130	Frank intox.
3	30	Frank intox.	135	Frank intox.
4	40	Mild intox.	130	Frank intox.
5	50	Frank intox.	140	Frank intox.
6	50	Mild intox.	153	Frank intox.
7	55	Mild intox.	130	Frank intox.
8	65	Frank intox.	130	Frank intox.
9	65	Mild intox.	155	Frank intox.
10	70	Mild intox.	155	Frank intox.
11	75	Frank intox.	130	Frank intox.
12	75	Frank intox.	160	Frank intox.
13	80	Frank intox.	165	Frank intox.
14	85	Mild intox.	130	Mild intox.
15	85	Mild intox.	130	Frank intox.
16	90	Mild intox.	175	Frank intox.
17	100	Frank intox.	140	Frank intox.
18	120	Frank intox.	180	Frank intox.

[a] Alcohol dosage, 1.1 to 1.2 gm/kg ingested in 20 minutes.

[b] Condensed from two tables in paper by Brinkmann et al. (7)

Immediately after the end of drinking, the cubital vein BAC values ranged from only 15 mg/100 ml to 120 mg/100 ml, but all 18 subjects were diagnosed as intoxicated, half of the subjects showing mild intoxication and half frank intoxication. The BAC peaks were reached in 10 to 90 minutes after the end of drinking and these peak values ranged from 130 to 180 mg/100 ml. At the peak time, two subjects had mild intoxication and the other 16 exhibited frank intoxication. All during the rising BAC phase, most subjects with cubital vein BAC values below 80 mg/100 ml exhibited frank intoxication. In most jurisdictions, the cubital vein BAC findings immediately after the end of the drinking period would have freed all but two of the 18 subjects from a charge of driving under the influence, but a quantitative breath analysis would probably have resulted in a charge of intoxication for all of the subjects. In this study, and in the other three mentioned in the preceding paragraph, no breath alcohol analyses were performed, which is a most unfortunate omission.

Discrepancies Between the G-C Intoximeter Readings and the Cubital Vein BAC

In Table I, included as study 24, are the results of the first investigation of the G-C Intoximeter by Schmutte *et al.* (34), in which the data from the scatter diagram in Figure 1 are estimated. Three other blood-breath correlations with this instrument are listed in Table I as studies 16, 25 and 26. The distribution of deviations is about the same in study 24 by Schmutte *et al.*, study 25-a by Hoday, and study 16 by Penton and Forrester. However, in study 25-b, and in study 26 by Morales, the G-C Intoximeter results are much better than those reported by Schmutte *et al.*

An inspection of Table I will show that, in eight of the correlation studies, 1, 3, 10, 14, 15, 18, 25-b, and 27, the breath instrument reading and the direct analysis of the subjects' blood agreed within ±10% for 70 out of 100 to 87 out of 100 of the blood-breath pairs, the average fraction being 79 out of 100. In six of these eight studies, the fraction of the total blood-breath pairs in which the deviation was beyond ±15% was only 2 out of 100 to 9 out of 100. Thus, the performance of some of these breath alcohol instruments does approach the ±10% limits of accuracy which the Hamburg commission would apparently accept.

In the U.S.A., several of the breath alcohol instruments listed in Table I have met the standards of accuracy adopted by the chemical test control agencies of some of the states, and the use of certain ones have been endorsed by the American Medical Association Committee on Medicolegal Problems (1).

Storage of Breath Samples

Contrary to the pronouncement of the Hamburg commission, reliable methods for storing the alcohol from a given volume of alveolar air have been published by Forrester (13), Jones (24), and Harger *et al.* (20). Also, Penton and Forrester (32) have developed a sterilized indium tube capsule in which alcoholic breath may be stored for months.

The Question of Compulsory Breath Analysis

The members of the Hamburg commission and their scientific advisors were apparently not familiar with the implied consent laws of the U.S.A. and several other countries. With this law, the subject is not forced to give a sample of his breath, but if he refuses his driver's license is suspended for several months. Fear of this penalty has resulted in very few refusals to furnish a breath sample.

Breath Analyses with Unwilling or Comatose Subjects

Harger *et al.* (21) have reported that, with the Drunkometer procedure employing the alcohol-CO_2 ratio, it is possible to make reasonably accurate breath alcohol analyses by using a rubber bulb pump to suck the expired air through the instrument after it has left the body and becomes common property.

ARTERIO-VENOUS AND VENO-VENOUS BAC DISCREPANCIES DURING RISING BAC

Arterio-Venous Discrepancies in BAC

As mentioned above, the Hamburg commission did recognize that there may be gross arterio-venous BAC discrepancies during rising BAC, and they point to such discrepancies in the BAC levels of cubital vein and pulmonary vessels, with the latter BAC controlling the alcohol concentration of alveolar air. However, they failed to give the primary physiological reason for the arterio-venous BAC difference. The reason is that the voluntary muscles, which comprise about 40% of the body weight, have relatively poor rate of flow of blood per kg of tissue, as compared with brain, liver and kidney, which reach alcohol storage equilibrium with the arterial blood within a few seconds. With the voluntary muscles, ½ to 1½ hours are required to reach alcohol storage equilibrium, and during this time the BAC of the venous return from these muscles lags far behind the corresponding arterial BAC, which, at all times, is practically identical throughout the circulatory system. During this period, there is usually an 'overshooting' of the alcohol concentrations in the arterial blood and in the tissues of the brain, liver, kidney, etc. having a very rich blood flow/min/kg. This abnormally high brain alcohol concentration may cause marked intoxication with very low cubital vein BAC. Here, a serious discrepancy between cubital vein BAC and alveolar breath alcohol concentration does not indicate an error in the breath analysis, *but an error in using cubital vein blood to estimate the degree of alcoholic impairment at this time.* A review of experimental evidence supporting the above statements appears in the 1963 paper of Harger (16), which was mentioned earlier. Later studies with humans by Forney *et al.* (12), and with rabbits by Gostomyzk *et al.* (15), give further confirmation of our explanation of the arterio-venous BAC differences and the resulting effects on the degree and course of the alcoholic impairment.

As long as the Hamburg authorities persist in confining their chemical tests for intoxication to cubital vein blood, they surely cannot expect a satisfactory agreement of their blood alcohol values with results from breath analysis, particularly during the rising BAC phase.

Veno-Venous Discrepancies in BAC of Bilateral Veins

A 1971 paper by Naeve *et al.* (30) describes a study in which 10 subjects ingested alcohol slowly during 1½ hours to give BAC values of 26 to 142 mg/100 ml within the following hour. They then ingested alcohol, 1 gm/kg in 10 minutes. Following this "sturztrunk", blood samples were taken simultaneously from the right and left cubital veins at 11 intervals during the next 2½ hours, and were analyzed by a modified Widmark method.

Of the 107 pairs of blood, the BAC of 76 agreed within ±7 mg/100 ml, while with the remaining 31 pairs, the right and left BAC values differed by 10 to 36 mg/100 ml, with an average discrepancy of 20 mg/100 ml. Figure 3 presents the results of this study.

We have translated these absolute deviations into per cent deviations and find that they range from 7% to 21%, with an average of 12.5%. When the per cent deviations for the 107 blood pairs are classified in the manner used in Table I, the deviation distribution becomes: within ±7%, 71 out of 100; within ± 10%, 84 out of 100; within ±15%, 93 out of 100; and beyond ±15%, 7 out of 100. A survey of the discrepancies between the BAC levels of right and left cubital veins, makes it evident that, in the simple matter of estimating the BAC of the right cubital vein from that of the corresponding left vein, or vice versa, the degree of inaccuracy is even greater than that of some of the breath alcohol procedures for estimating BAC. It is true that the rate of alcohol intake in the "sturztrunk" is abnormal, but it should be noted that the veno-venous discrepancies continued, unabated, for 2½ hours after the "sturztrunk". From these results, one wonders if some of the blood-breath correlations using cubital vein blood, which have been reported in the literature, might have been different if the opposite cubital vein had been the blood source.

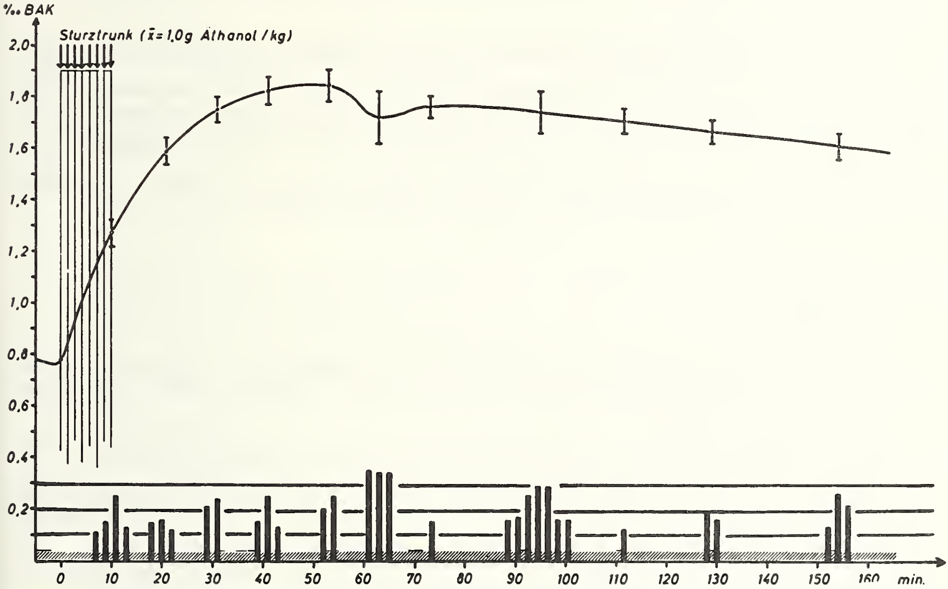


Figure 3 *Significant deviations between BAC of right, and of left, cubital veins of 10 subjects at 11 time intervals during 2½ hours after ingestion of alcohol, 1 gm/kg, in 10 minutes ("Sturztrunk" = drinking spurt). Ordinate scale, $^{o}/oo$ (mg/ml); to translate to mg/100 ml, multiply by 100. Each black column is the BAC difference for a single veno-venous pair. These comprise 31 of the 107 veno-venous pairs. Only differences above 0.1 $^{o}/oo$ (10 mg/100 ml) are given. Shaded area, average analytical error. Curve, average BAC for the 10 subjects, with standard deviations. We have added three parallel lines to facilitate calculation of the approximate per cent deviation. From Naeve et al. (30).*

A 1974 paper by Teige *et al.* (38) reports an extensive follow-up study of this matter, and states that they could not confirm the findings of Naeve *et al.* However their experimental procedures differed significantly. In the experiment of Teige *et al.* each subject's forearms were immobilized by being held to the arms of his chair, and indwelling catheters remained in the cubital veins during the blood sampling period of two to four hours, with blood samples drawn at one minute or two minute intervals. With the subjects used by Naeve *et al.*, if one forearm was inadvertently exercised more than the other during the experimental period, the difference in rate of blood flow to the tissues of the two forearms might have caused one to reach storage equilibrium much sooner than the other, altering the BAC of the venous return. Also, the indwelling catheters may have somewhat impeded the venous return from both arms.

At any rate, the study by Teige *et al.* covered 667 veno-venous pairs and the deviations for 94% of the pairs were within ±8 mg/100 ml. With the remaining pairs, the deviations ranged from ±9 mg/100 ml to ±16 mg/100 ml. With one subject, the paired samples read 112 and 110 mg/100 ml at 30 minutes, fell to 92 and 96 mg/100 ml at 33 minutes, and then rose to 110 and 108 mg/100 ml at 44 minutes. The maximum change was 20 mg/100 ml in three minutes, indicating at least some inconstancy in cubital vein BAC.

CONCLUDING REMARKS

We trust that our Hamburg co-workers will continue their investigations of quantitative breath alcohol instruments, testing not only the improved G-C Intoximeter, but also several other instruments that show reasonable accuracy (Table I). In these further studies, we hope they will employ arterial blood, or at least fingertip blood, *but not cubital vein blood during rising BAC.* They might also try rebreathed air, which yielded about the best blood-breath correlations listed in Table I.

REFERENCES

1. Anon., Tests for the Determination of Ethyl Alcohol, in *Manual on the Medicolegal Aspects of Chemical Tests for Intoxication*, C. H. Hine (Ed), American Medical Association, Chicago, 1970. Chapter VI.
2. Anon., Breath Alcohol Testing Cannot Replace Blood Alcohol Determinations, International Comments, *Journal of the American Medical Association,* **226**, 1129 (1973).
3. Bayly, R. C., McCallum, N.E.W. and Preston, W.E.L., The Determination of Blood Alcohol Concentration by Breath Analysis, *Proceedings of the Royal Australian Chemical Institute* 27, 157 (1960).
4. Begg, T. B., Hill, I. D. and Nickolls, L. C., Breathalyzer and Kitagawa-Wright Methods of Measuring Breath Alcohol *British Medical Journal* I, 9-15 (1964).
5. Bonte, W., Philipp, J-H. and Berg, S., Results of Breath Alcohol Analyses with the "Alcolinger-Automatic" in the Absorption Phase, *Blutalkohol* 7, 454-462 (1970).
6. Brinkmann, B., Koops, E. and Naeve, W., The Course of the Blood Alcohol Curve in the Early Phase After the End of Drinking, *Blutalkohol* 9, 94-98 (1972).
7. Brinkmann, V. B., Wilhelmi, F., Naeve, W. and Janssen, W., Rapid Drinking (Sturztrunk) and Degree of Intoxication at Low Blood Alcohol Concentrations, *Beitrage zur Gerichtlichen Medizin* 30, 65-71 (1973).
8. Chastain, J. D., Strauss, H. J. and Maupin, C. W., *A Correlation Study of Blood Alcohol Levels as Determined by Alcometer, Breathalyzer and Direct Blood Analyses Including Blood-Urine Ratio.* Texas Department of Public Safety, Austin, Texas, 1957.
9. Coldwell, B. B., and Smith, H. W., Alcohol Levels in Body Fluids After Ingestion of Distilled Spirits, *Canadian Journal of Biochemistry and Physiology* 37, 43-52 (1959).
10. Day, M., Muir, G. G. and Watkins, J., Evaluation of 'Alcotest R80' Reagent Tubes, *Nature* 219, 1051-1052 (1968).
11. Fennell, E. J., Address in Panel on Chemical Tests, *Proceedings of the Symposium on Alcohol and Road Traffic*, Indiana Univ., 1958, Department of Police Administration, Indiana University, Bloomington, Indiana (1969). Pp 88-109.
12. Forney, R. B., Hughes, F. W., Harger, R. N. and Richards, A. B., Alcohol Distribution in the Vascular System; Concentration of Orally Administered Alcohol in Blood from Various Points in the Vascular System, and in Rebreathed Air, During Absorption, *Quarterly Journal of Studies on Alcohol* 25, 205-217 (1964).
13. Forrester, G. C., *Photoelectric Intoximeter Manual.* Intoximeter Association, Niagara Falls, N.Y., 1958.

14. Franklin, S., A Comparison of Whole Blood:Breath Correlations with Blood Plasma:Breath Correlations for Alcohol Concentrations, *Proceedings of the 5th International Conference on Alcohol and Traffic Safety, Freiburg*, W. Germany, 1969, Schulz, Freiburg, 1970. Pp. II, 99-103.

15. Gostomyzk, J., Dilger, B. and Dilger, E., The Distribution of Intravenously Administered Substances in the Body as Exemplified by Ethyl Alcohol *Blutalkohol* 6, 340-52 (1969).

16. Harger, R. N., Blood Source and Alcohol Level; Errors from Using Venous Blood During Active Absorption, *Proceedings of the 3rd International Conference on Alcohol and Road Safety, London, 1962*, British Medical Association, London, 1963. Pp. 212-219.

17. Harger, R. N., and Forney, R. B., Aliphatic Alcohols, in *Progress in Chemical Toxicology*, A. Stolman (Ed) Vol. 1, Academic Press, New York, 1963. Pp. 107-122.

18. Harger, R. N., and Forney, R. B., Aliphatic Alcohols, in *Progress in Chemical Toxicology*, A. Stolman (Ed), Vol. 3, Academic Press, New York, 1967. Pp. 46-55.

19. Harger, R. N., and Forney, R. B., The Temperature of Rebreathed Air, and the Arterial Blood:Rebreathed Air Alcohol Ratio, *Proceedings of the 5th International Conference on Alcohol and Traffic Safety*, Freiburg, W. Germany, 1969, Schulz, Freiburg, 1970. Pp. II, 73-78.

20. Harger, R. N., Forney, R. B. and Baker, R. S., Estimation of the Level of Blood Alcohol from Analysis of Breath; Use of Rebreathed Air, *Quarterly Journal of Studies on Alcohol* 17, 1-18 (1956).

21. Harger, R. N., Lamb, E. B. and Hulpieu, H. R., A Rapid Chemical Test for Intoxication Employing Breath; a New Reagent for Alcohol and a Procedure for Estimating the Concentration of Alcohol in the Body from the Ratio of Alcohol to Carbon Dioxide in the Breath, *Journal of the American Medical Association* **110**, 779-785 (1938).

22. Harte, R. A., An Instrument for the Determination of Ethanol in Breath in Law Enforcement Practice, *Journal of Forensic Sciences* 16, 493-510 (1971).

23. Hoday, J., Chm., Canadian Special Committee on Breath Testing, Unpublished report to M. R. Forrester, 1973.

24. Jones, T. P., Breath Alcohol Analysis with the "Alcolyser ASC" (Alcohol Sampling Collector), *Proceedings of the 5th International Conference on Alcohol and Traffic Safety*, Freiburg, W. Germany, 1969, Schulz, Freiburg, 1970. Pp. II, 41-46.

25. Lamprecht, J., and Leuschner, K., *The Reliability of Methods of Breath Alcohol Analysis for Estimating the Blood Alcohol Concentration in Forensic Cases* (Ger), Hamburg Government Document No. 353, 1973.

26. Machata, G., Gaschromatographic Determination of Blood Alcohol (Ger.), *Blutalkohol* 4, 252-260 (1967).

27. Monnier, D., Determination of Alcohol in Breath (Fr), *Proceedings of the 4th International Conference on Alcohol and Traffic Safety, Indiana University, Bloomington, Indiana, 1965*, Department of Police Administration, Indiana University, Bloomington, Indiana, 1966. Pp. 170-177.

28. Morales, D. R., *Summary of Activities Relating to Evaluation of Instruments and Related Accessories for Breath Alcohol Analysis*, Clinical Chemistry Laboratory, California State Department of Health, Berkeley, California, 1972: Report No. 2, 1974.

29. Naeve, W., and Brinkmann, B., Blood Alcohol Level and Degree of Intoxication after Rapid Drinking (Sturztrunk) (Ger.), *Blutalkohol* 8, 42-52 (1971).

30. Naeve, W., Koops, E., Audrlicky, I. and Brinkmann, B., Veno-Venous Differences in Blood Alcohol Concentration after Rapid Drinking (Sturztrunk) (Ger.), *Blutalkohol* 8, 451-456 (1971).

31. Naeve, W., Schmidt, C., Brinkmann, B. and Janssen, W., Alcohol Effects in the Absorption Phase with Maximum Blood Alcohol Values of About 0.7 to 1.0 $^{0}/oo$ (70 to 100 mg%) (Ger.), *Blutalkohol* 11, 145-154 (1974).

32. Penton, J. R., and Forrester, M. R., A Gas Chromatographic Breath Analysis System with Provisions for Storage and Delayed Analysis of Samples, *Proceedings of the 5th International Conference on Alcohol and Traffic Safety, Freiburg, W. Germany, 1969*, Schulz, Freiburg, 1970. Pp. II, 79-86.

33. Prouty, R. W., and O'Neill, G. G., *An Evaluation of Some Qualitative Breath Screening Tests for Alcohol.* Research Report, Insurance Institute for Highway Safety, Washington, D.C., 1968.

34. Schmutte, P., Naeve, W., Wilhelmi, F., and Brinkmann, B., Comparative Studies of Blood Alcohol and Breath Alcohol Concentrations with Gas Chromatographic Breath Test (Intoximeter) (Ger.), *Blutalkohol* 9, 392-399 (1972).

35. Schmutte, P., Stromeyer H. and Naeve, W., Comparative Study of Breath and Blood Alcohol Concentration after Physical Exercise and Special Breathing Technique (Hyperventilation) (Ger.), *Blutalkohol* 10, 34-42 (1973).

36. Scroggie, J. C., Some Aspects of Recent Australian Research in Breath Tests for Alcohol, *Proceedings of the 3rd International Conference on Alcohol and Road Traffic, London, 1962*, British Medical Association, London, 1963. Pp. 272-276.

37. Shupe, L.M. and Pfau, R. O., Alco Analyzer Gas Chromatograph, *Proceedings of the 5th International Conference on Alcohol and Traffic Safety, Freiburg, W. Germany, 1969*, Schulz, Freiburg, 1970. Pp. II, 67-72.

38. Teige, K., Niermeyer, H., Gerlach, D., Bohn, G. and Brauer, G., Differences in the Blood Alcohol Concentration with Simultaneous, Almost Continuous, Blood Sampling from the Corresponding Veins of the Right and Left Arms (Ger.), *Blutalkohol* 11,29-39 (1974).

39. v. Below, G., Breath Alcohol Determination With the Breathalyzer From a Legal Standpoint, (Ger.), *Blutalkohol* 7, 315-317 (1970).

Involvement of Alcohol, Carbon Monoxide and Other Drugs in Traffic Fatalities

Robert F. Turk, Arthur J. McBay[1,2]
Page Hudson, and Marilyn M. Bullaboy

Traffic crashes are the leading cause of accidental injury and death in the State of North Carolina.[3] In many traffic deaths drugs are directly or indirectly involved. The drug which has been reported to constitute a major factor in at least half of all traffic fatalities is ethyl alcohol (20, 21). Studies concerning the involvement of drugs other than ethyl alcohol in fatal automobile crashes are a recent phenomenon.

One of the first efforts to analyze for drugs (other than alcohol) in automobile fatalities was that of Sullivan (18). Sullivan's study which was limited to single-vehicle driver deaths, found that drugs other than ethyl alcohol were present in some of these fatalities. Rehling (17) conducted a study in which he analyzed blood specimens from 476 traffic fatalities for ethyl alcohol, drugs, and carbon monoxide. It was found that the major drug involved was ethyl alcohol and that only 2% of these traffic victims contained other drugs. Of this 2% (10 drugs), quantitative blood drug levels were given on only three specimens: two of these specimens contained methanol and one contained secobarbital. Rehling's study revealed that 5% of the samples contained a significant level of carbon monoxide and eleven of these also contained ethyl alcohol. The study does not report whether the significant carbon monoxide levels were due to gasses produced by a fire in the automobile caused by the crash.

Nichols (15) has written an extensive review concerning the present status of knowledge in the field of drugs and driving. He reported on seven studies which were concerned with single-vehicle crash fatalities. The major drug detected was ethyl alcohol and other drugs were detected in 4.5% to 9% of the population under study.

Nichols (15) also reviewed the literature on studies of both multiple and single crashes. Where analyses of tissues were reported, drugs were found in 3-7% of the cases.

A recent report by Turk *et al.* (20) indicated ethyl alcohol involvement in 61% of the single-car crashes and other drugs in only 3% of the crashes investigated. All such drugs were present in conjunction with ethyl alcohol. The same authors investi-

---

[1] Chief Toxicologist, Division of Health Services, Office of the Chief Medical Examiner, P.O. Box 2488, Chapel Hill, North Carolina 27514, U.S.A.

[2] The statistical assistance of Nancy J. Hamrick is gratefully acknowledged. This work was supported in part by grant No. FA-308 from the U.S. Department of Transportation, Federal Highway Administration, National Highway Safety Bureau.

[3] Detailed Mortality Statistics 1972 North Carolina Residents, Department of Human Resources, Division of Health Services, Administrative Services Section, Public Health Statistics Branch, P.O. Box 2091, Raleigh, North Carolina 27602.

gated pedestrian fatalities and found that 54.4% had alcohol present in their tissue; 6.1% had a drug and ethyl alcohol; and 15.2% had drugs alone.

It is difficult to obtain information concerning drug use from non-fatal crashes because biological samples cannot be taken legally from the victim without consent. Nichols (15) reviewed the little information available concerning drug use and non-fatal crashes.

Several investigators have observed through controlled studies that a drug alone or in combination with alcohol can impair driving ability. These studies have used either driving simulators or prescribed driving courses (3, 4).

METHODS

Fatal injuries to operators or pedestrians, resulting from automobile crashes, were the subject of analysis. The crash victims who were studied were 15 years of age or older, and must have died at the scene of the crash or have been dead on arrival at the hospital. The medical examiners responsible for the county in which a death had occurred submitted blood, liver and urine in containers furnished by the Office of the Chief Medical Examiner. The blood was placed in a 25 ml container which contained 0.25 g of sodium fluoride as preservative. All samples were shipped by first class mail to the Toxicology Laboratory of the Office of the Chief Medical Examiner in Chapel Hill, North Carolina. All medical examiners working with the project were given mailing instructions for handling the project samples.. The receipt of the required samples (blood, liver and urine) was recorded in the project log book.

Tissue specimens from a total of 251 fatalities were examined for the presence of drugs and carbon monoxide. This represented 171 automobile operators and 62 pedestrians (18 fatalities after examination did not meet the criteria of the study). Liver sections from 233 fatalities were examined microscopically for evidence of pathological changes due to chronic alcoholism.

Methods of Toxicological Analysis of Specimens

Blood. Blood was examined for the presence of ethyl alcohol and other volatiles according to the method described by McBay (11). Positive samples were analyzed by gas-liquid chromatography according to the method of Parker *et al* (16). This is a qualitative as well as a quantitative method for detection of ethyl alcohol and other volatiles. The blood was analyzed for carbon monoxide concentration by the method described by Freireich and Landau (10). It was analyzed for salicylates by the method described by Trinder (19). Blood was also analyzed by the method described by Finkle (7). This method employed gas chromatography to detect the presence of weak acids, bases and neutral drugs when present in the blood. If a peak was detected, the retention time was compared to retention times of known drugs reported by Finkle for his method. If the drug was an acid (barbiturates or diphenylhydantoin) or a neutral, then the barbiturate method of Barrett modified for our Laboratory was followed (1).

Every blood sample was analyzed for the presence of morphine. The method used for this analysis was that of Mulé and Hushin (14) modified for our laboratory (12).

Liver. Liver was extracted for organic base compounds according to a laboratory method described by Curry (2). The presence of methaqualone and propoxyphene, as well as other organic base compounds, may be detected by this method. If propoxyphene was detected in the liver, using this method, then the propoxyphene method of McBay *et al* (13) was used to quantitate propoxyphene in the liver and blood.

When no identifiable ultraviolet absorption spectrum was obtained, the extract was examined by thin-layer chromatography (TLC) and by gas-liquid chromatography (GLC).

Microscopic examination of each liver section was performed by the Chief Medical Examiner to determine the presence and extent of pathological changes likely due to alcohol abuse. Each liver section was stained with hemotoxylin and eosin before microscopic examination. The pathological changes were then classified according to the following classifications:

Negative:	No fatty vacuolization present.
Trace:	Rare isolated vacuole of questionable significance. These were treated as 'negatives', although the suspicion should remain that these were really a milder example of alcohol abuse effect than the other cases.
Positive, plus one to plus four:	Increasing scale ranging from scattered, but easily perceptible, vacuoles of varying sizes up to or almost complete replacement of the cytoplasm of most hepatic cells by vacuoles.
Laennec's Cirrhosis:	Classic, textbook microscopic characteristics were used. (Examples of other types of cirrhosis were occasionally encountered, but were not considered alcohol-related.)

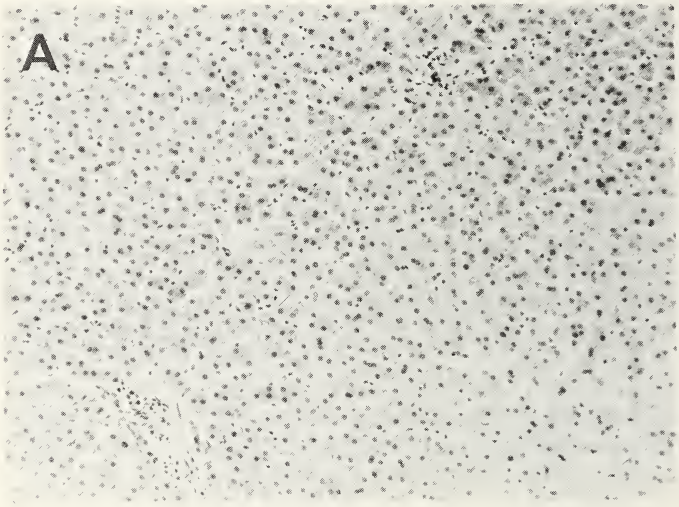
The microscopic sections of liver had previously been coded by one author and submitted for examination by a forensic pathologist who did not know the history of the cases or the blood alcohol concentrations. (Figure 1).

Urine. Several analyses were performed on each urine specimen:

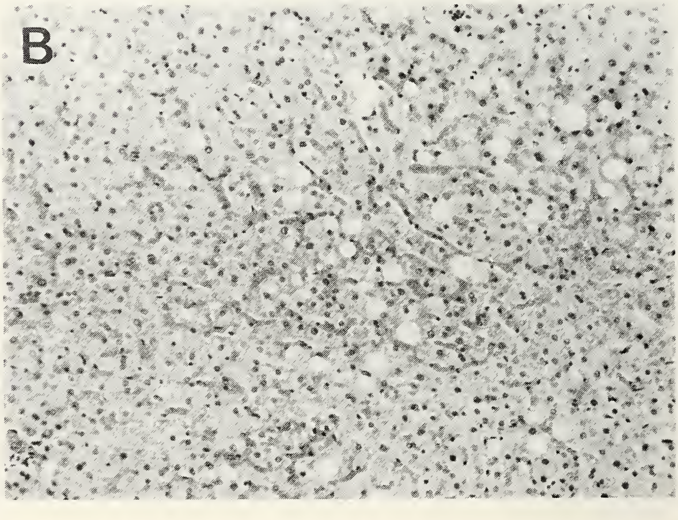
1. An "FPN" – Universal Test as described by Forrest and Forrest (8), was performed on an aliquot of urine for the presence of phenothiazines.
2. A test for Imipramine was made on each urine (9).
3. Test for presence of ethchlorvynol was performed (5).
4. A test for morphine was performed according to the modified method of Mulé and Hushin (14).
5. A thin-layer chromatographic urine drug analysis was performed according to the method of Davidow (6) modified by Dal Cortivo (5). If a positive thin-layer chromatographic response was obtained, the spot was scraped from the TLC plate and its identification was confirmed by gas-liquid chromatography. Once the presence of a drug was confirmed, the blood and liver were analyzed.

Conclusion on Methodology

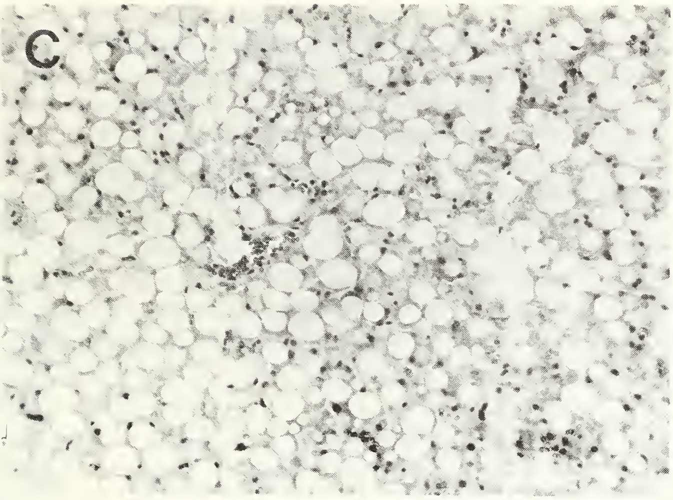
The methods used in this study for the detection of drugs in biological tissue have limitations. The most notable limitation was the inability of existing laboratory techniques to detect the presence of the psychoactive drugs d-Lysergic acid diethylamid (LSD) and marihuana in biological samples. Another group of drugs, the benzodiazepines, used in psychiatric disorders and as minor tranquillizers were difficult to detect in therapeutic concentrations with the then available methodology. The methodology used in this study allowed for the detection of most of the commonly prescribed drugs. Methodology for the detection of LSD, marihuana and the benzodiazepines which could not be detected in biological samples when this study began have just recently been developed. These include sophisticated electron capture gas chromatography, radioimmunoassay, and gas chromatographic mass spectrometry.



(A)



(B)



(C)

Figure 1 *Hemotoxylin and eosin stain. (A) Normal liver. (B) "2+ fatty liver," scattered hepatocytes containing intracytoplasmic lipid vacuoles of varying size. (C) "4+ fatty liver," replacement of most of cytoplasm by liquid vacuoles. Original magnification x 150.*

RESULTS AND DISCUSSION

Single-Car Crash Operators

The major drug which was detected in this group was ethyl alcohol. In deaths where another drug was involved, alcohol was also detected (Tables I and IV). In two of these four deaths a therapeutic level of drug was detected; however, there was also a sufficient quantity of ethyl alcohol present to be the sole cause of driver impairment. These two fatalities represent a possible additive effect between alcohol and another drug which would probably cause more severe impairment of driver ability than if either the alcohol or drug was present by itself (Table III). The blood of one of these two fatalities had a propoxyphene concentration of 0.07 mg/100 ml (mg%) and an alcohol concentration of 270 mg%.

TABLE I *Summary of Findings*

Type of Fatality	Total	Drugs Detected		Alcohol Alone Detected		Drugs Alone Detected		Drugs Plus Alcohol Detected	
		N	%	N	%	N	%	N	%
All Operators	171	99	57.9	64	37.4	3	1.8	5	2.9
Single-Car Crash Operators	72	22	30.6	46	63.9	0	0	4	5.6
Multiple-Car Crash Operators	99	77	77.8	18	18.2	3	3.0	1	1.0
Pedestrians	62	26	41.9	31	50.0	3	4.8	2	3.2

The blood of one of the other 4 deaths had a phenacetin concentration of 1.6 mg% which is in the therapeutic range along with an alcohol concentration of 270 mg%. The alcohol concentration alone, as in the previous two described deaths, was sufficient to cause driver impairment. The combination of phenacetin and alcohol has not been shown to have an additive effect.

The blood of the remaining fatality had a phenobarbital concentration of 0.4 mg%, which is in low therapeutic range and a BAC of 30 mg%, amounts which by themselves would not necessarily cause impairment of driver ability. However, barbiturates and alcohol are known to have an additive effect.

In the single-car crash population, alcohol was detected in the blood of 63.9% of the fatalities. Of these, 27.8% had BACs above 100 mg% and 29.2% were above 200 mg%. The mean positive BAC represented by this group was 179 mg%.

TABLE II *BACs of Fatally Injured Operators and Pedestrians*

BAC (mg/100 ml)	Single Crash Operators[a] N	%	Multiple Crash[b] Operators N	%	Pedestrians[c] N	%
Negative	22	30.6	80	80.8	28	45.2
30-49	2	2.8	0	0	2	3.2
50-99	7	9.7	5	5.1	3	4.8
100-199	20	27.8	7	7.1	8	12.9
200-299	18	25.0	7	7.1	15	24.2
300-399	2	2.8	0	0	4	6.5
400-499	1	1.4	0	0	2	3.2

[a] Mean positive BAC = 179 mg/100 ml.
[b] Mean positive BAC = 158 mg/100 ml.
[c] Mean positive BAC = 228 mg/100 ml.

Microscopic examinations of the livers of 63 driver-victims of single-car crashes were made. The blood of 18 of the 63 had no alcohol. The livers of five of these 18 had distinct fatty changes indicative of chronic alcohol abuse. The livers of 29 of the 63 single-car driver group examined microscopically had changes highly indicative of chronic alcohol abuse. The findings in the livers were equivocal in an additional five of the 63 and the blood of all five had alcohol concentrations between 100 and 300 mg%.

Multiple-Car Crash Operators

The drug most often encountered in this group was ethyl alcohol; however, drugs alone and in conjunction with ethyl alcohol were also encountered (Tables II and III). Drugs other than alcohol were detected in the tissues of 3% of the fatalities and were represented by the sedative-hypnotic, phenobarbital, the anti-arrhythmic drug quinidine, and by quinine. In one fatility alcohol plus quinine was detected in the urine; however, in this one fatality the alcohol concentration alone was 130 mg% and a driver with this concentration would be impaired. The quinine in both fatalities was found only in the urine.

The major problem with assessing the effect of drugs in multiple-car fatal crashes is that specimens from both operators may not be available for analysis. Thus, drug involvement in multiple crashes is virtually unknown in this state.

Microscopic examinations of the livers of 94 of these operator-victims were performed. Thirty-two had no alcohol in their blood but had fatty changes of the liver or had Laennec's cirrhosis. Of 13 of these with equivocal fatty change, 10 had no alcohol in their blood. The livers of 43 of the 94 examined had distinct changes indicative of chronic alcohol abuse; 13 more had equivocal changes.

Pedestrians

Alcohol alone was detected in the blood of 50% of the pedestrian fatalities; other drugs alone were detected in the blood of 4.8% of these fatalities and 3.2% had alcohol in combination with another drug.

In this group 12.9% had BACs of 11 mg% or more and 33.9% were above the 200 range. BACs between 300 and 399 mg% were found in 6.5% of the cases and 3.2% had concentrations above 400 mg%. It was reported that in a few of these fatalities the individual was actually lying on the road surface when struck. This phenomenon was associated with BACs of 300 mg% and above (Table II).

Other drugs which occurred without alcohol in tissues were slow-acting barbiturates, found in two fatalities; and a combination of 1.0 mg% amobarbital and 0.9 mg% secobarbital, which was found in one fatality (Table III).

Pedestrians were only studied if fatally injured, which, as in the auto fatalities, was a built-in bias in the study. In order to determine the true drug occurrence, specimens from both the fatally injured as well as the non-fatally injured operator and pedestrian involved in an auto crash need to be analyzed for drugs and compared to the normal population. Legal obstacles must be overcome if this is to be accomplished.

The livers of 56 of the pedestrians were examined for changes indicative of alcohol abuse. The hepatic changes of 25 of this group were highly indicative of chronic alcohol abuse. Alcohol was found in the blood of 18 of the 25. Five of the ten victims whose liver had equivocal microscopic changes also had positive BACs. Twenty-four of the 56 pedestrian victims tested had no alcohol in their blood.

Carbon-monoxide

Significant amounts of carbon monoxide were detected in the blood of 3 crash fatalities. The first of these fatalities involved a crash in which the automobile was consumed by fire. The carbon monoxide in the blood of the operator was 40% of saturation. This indicates he was alive following the crash. The operator's blood had an alcohol concentration of 220 mg% and a propoxyphene concentration of 0.07 mg%. The inference is, if the driver was not unconscious after the crash he could have been greatly impaired from escaping the fire due to the alcohol and propoxyphene blood concentrations.

The second crash victim's blood was 40% saturated with carbon monoxide and the third crash victim's blood was 45% saturated with carbon monoxide. In both the second and third fatality the operator was alive following the crash.

For this study the average blood carbon monoxide was 5.8% of saturation. This average blood saturation excludes the three fatalities just described.

TABLE III *Type of Crash, Drug and BAC Level*

Type of Crash	Drug Detected	Drug/ Blood Level (mg%)	BAC (mg/100 ml)
Single-Car	1. Phenobarbital	0.4	30
	2. Phenacetin	1.6	270
	3. Propoxyphene	0.07	220
	4. Phenobarbital	0.8	170
	plus Dilantin	0.5	
Multiple-Car	1. Quinidine	0.1	Negative
	2. Phenobarbital	0.2	Negative
		Urine Level	
	3. Quinine	Positive	Negative
	4. Quinine	Positive	130
Pedestrian	1. Slow-Acting Barbiturate	2.0	Negative
	2. Phenobarbital	0.15	Negative
	3. Phenobarbital	0.3	320
	4. Salicylate	9.5	220
	5. Amobarbital	0.98	Negative
	plus Secobarbital	0.94	

Positive Drug Findings

The blood samples of the pedestrians had a higher positive mean alcohol concentration (228 mg%) than that of the single-car operators (179 mg%) or that of the multiple-car crash operators (157 mg%). It cannot be emphasized enough that no conclusion can or should be drawn concerning the multiple-car crash operator because only specimens from the fatally injured driver was analyzed for drugs, not necessarily the responsible driver. A similar situation exists for pedestrian fatalities. Drugs could have been involved but only specimens from the fatally injured pedestrian not the operator, were analyzed for drugs.

If those fatalities in which drugs were found are considered separately, alcohol was found in samples from 92% of the operators in single-car crashes and other drugs were found in samples from 8%. In multiple-car crashes, alcohol was found in samples from 82% of the operators while 14% had positive levels of drugs other than alcohol, and 4% had positive levels of drugs plus alcohol. Ethyl alcohol alone was found in samples from 86% of the pedestrian fatalities, other drugs alone were found in 8%, and a combination of other drugs plus alcohol in 6%. In all three categories, ethyl alcohol is by far the drug most commonly encountered (Table IV).

Driver Records

Finally, an attempt was made to correlate alcohol impairment and the driving records of fatally injured drivers. There were 128 driver's records obtained in this study. Of

TABLE IV *Positive Drug Cases*

Type of Case	Drug Detected N	Alcohol Alone Detected %	Drugs Alone Detected %	Drugs Plus Alcohol Detected %
All Operators	72	89	4	7
Single-Car Crash Operators	50	92	0	8
Multiple-Car Crash Operators	22	82	14	4
Pedestrians	36	86	8	6

those unimpaired by alcohol 48 had previous driving violations and 31 had no previous record. Of those impaired by alcohol 37 had previous driving violations and 12 did not.

SUMMARY AND CONCLUSION

This report presents the results of a three-year study of the involvement of drugs and carbon monoxide in automobile operators and pedestrians killed in six counties of North Carolina.

It reveals that the major drug detected in operators and pedestrians fatally injured in automobile crashes was ethyl alcohol. Drugs other than alcohol most frequently encountered were the sedative hypnotics which were represented by the barbiturates; the analgesics, represented by propoxyphene, salicylates and phenacetin; the antiepileptic drug, diphenylhydantoin; the antiarrhythmic drug, quinidine and lastly, the antimalarial drug and also a common ingredient in tonic water and "street" heroin, quinine.

Microscopic examination indicated that the livers of at least half of the drivers and pedestrians showed evidence that they had been chronic alcoholics. This indicates a gross over-representation of alcoholics among the driver crash victim and the pedestrian crash victim populations.

REFERENCES

1. Barrett, J. M., An Integrated Gas Chromatographic Program for Drug Screening in Serum and Urine. *Clinical Chemistry Newsletter* 3 (1), 1-10 (1971).
2. Curry, A., *Poison Detection in Human Organs,* Thomas, Springfield, Illinois, 1969.
3. Crancer, A., Jr., Dille, J. M., Delay, J. C., Wallace, J. E., and Haykin, M. D., The Effects of Marijuana and Alcohol on Stimulated Driving Performance, *Science* 164, 851-855 (1969).
4. Crancer, A. and Quiring, D. L., Driving Records of Persons Arrested for Illegal Drug Use, Report 011 Division of Research, Washington Department of Motor Vehicles (1968).
5. Dal Cortivo, L., Personal Communication. Presented at the Second Interim Toxicology Meeting in October of 1971 at Sulfolk County, N.Y.

6. Davidow, B., Petri, N. L., and Quame, B., A Thin-layer Chromatography Screening for Detecting Drug Abuse. *The American Journal of Clinical Pathology* **50**, 714-719 (1968).
7. Finkle, B. S., Cherry, C. J., and Taylor, D. M., A GLC Based System for the Detection of Poisons, Drugs and Human Metabolites Encountered in Forensic Toxicology. *Journal of Chromatographic Science*, 393-419 (1971).
8. Forrest, I. S., and Forrest, F. M., Urine Color Test for the Detection of Phenothiazine Compounds. *Clincial Chemistry* **6**, 11-15 and 362-363 (1960).
9. Forrest, I. S., and Forrest, F. M., and Mason, A. S., A Rapid Urine Color Test for Imipramine. *American Journal of Psychiatry* **116**, 840 (1960).
10. Freireich, A. W. and Landau, D., Carbon Monoxide Determination in Postmortem Clotted Blood. *Journal of Forensic Sciences* **16**, 112-119 (1971).
11. McBay, A. J., Ethanol, Type A Procedure. *Manual of Analytical Toxicology*, Irving Sunshine (Ed.), CRC Press, Cleveland, Ohio, 1971, p. 142.
12. McBay, A. J. and Turk, R. F., Heroin Deaths. *Bulletin of the International Association of Forensic Toxicologists* **8** (5), 12-13 (1972).
13. McBay, A. J., Turk, R. F., Corbett, B. W., and Hudson, R. P., Determination of Propoxyphene in Biological Tissue. *Journal of Forensic Sciences* **19**, 81-89 (1974).
14. Mulé, S. J., and Hushin, P. L., Seimautomated Fluorometeric Assay for Submicrogram Quantities of Morphine and Quinine in Human Biological Material. *Analytical Chemistry* **43**, 708-711 (1971).
15. Nichols, J. L., Drug Use and Highway Safety: A Review of the Literature, DOT HS-800-580, U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, D.C., July, 1971.
16. Parker, K. D., Fontan, C. R., Yee, J. L., and Kirk, P. O., Chromatographic Determination of Ethyl Alcohol in Blood for Medicolegal Purposes. *Analytical Chemistry* **34**, 1234-1236 (1962).
17. Rehling, C. J., The Role of Alcohol, Drugs, and Carbon Monoxide in Alabama Traffic Deaths. Governor's Highway Safety Program, Alabama, 1971.
18. Sullivan, H., A Report on Alcohol, Drugs, and Organic Factors in Fatal Single Vehicle Traffic Accidents. State of California, Department of the Highway Patrol, 1965.
19. Trinder, P., Rapid Determination of Salicylate in Biological Fluids. *Biochemical Journal* **57**, 301-303 (1954).
20. Turk, R. F., McBay, A. J., and Hudson, P., Drug Involvement in Automobile Driver and Pedestrian Fatalities. *Journal of Forensic Sciences* **19**, 90-97 (1974).
21. Waller, J. A., Holiday Drinking and Highway Fatalities. *Journal of the American Medical Association* **206**, 2693-2697 (1968).

"Will the Real Drugged Driver Please Stand Up?" An Analytical Toxicology Assessment of Drugs and Driving

Bryan S. Finkle[1]

Surely, the jig is up for the Drinking Driver. For the past forty years he has been surveyed, studied and described. He has had his behavior, his body fluids and his very breath analyzed by the most pedantic techniques of science, until Project Managers and Researchers have revealed him in detail; and made "Drunk Driver" and "Problem Drinker" household clichés. But what of the "Drugged Driver"?

Is there a danger that, by logical progression and without relevant knowledge, a specter is being created and legislated for the Drugged Driver? Unidentified, and cloaked in a veil of fear by a generation familiar with drug-abuse, it is natural to assume that drugs play a role in the current highway carnage. Millions of law-abiding citizens drive under the influence of drugs every day; but whether this is a significant factor in the total picture of traffic safety and requires priority attention is an important but unresolved question.

PROBLEM DEFINITION

An examination of available facts reveals: an alarming diversity of conflicting opinion by researchers; strong laws *already* in the statute books of most states; and totally inadequate analytical toxicology to support enforcement of the laws. This dilemma results from a common human propensity to put the cart before the horse; to promulgate laws to regulate a subjectively apparent social problem without thorough study of needs and priorities and before the means for effective enforcement has been developed.

The requirements to rectify this unhappy situation lie in addressing the following critical points: 1. Is there a real drugged-driver who needs legal attention? 2. If there is, are the laws appropriate? 3. Is current analytical capability and understanding of the forensic toxicology involved sufficient to support law enforcement? It is important to deal with these points, because there are few things more costly, time-consuming and frustrating than the development of legislation and the attempt to apply countermeasures to a problem which has not been defined – and in fact may not exist.

---

[1] Center for Human Toxicology, University of Utah, Salt Lake City, Utah 84112, U.S.A.

DISCUSSION

A casual reading of recent research reports concerned with drugs and driving, at least from a social-science, demographic perspective, clearly shows a lack of urgency on the part of the authors. For example, the Department of Transportation March 1974 report on Alcohol, Drugs and Driving, drug countermeasures research did *not* receive a high priority rating (8). Kibrick and Smart (5) Nichols (7) and Milner (6) all reached similar conclusions, that is, "At present there appears to be no need for greater legal countermeasures against drug use and driving". However, a similar reading of reports which include drug-analysis of blood or urine samples from drivers indicates an apparently serious conflict concerning this conclusion. The conflict stems entirely from the heterogeneous nature of the studies and limited scope of the analyses. Most were confined to selected populations, such as victims in fatal accidents, or single vehicle accidents, juvenile drug abusers, methadone clinic patients and urban drivers. Similarly, the range of drugs included in the analysis was narrow – sometimes to the extreme of a single agent (e.g. carbon monoxide) or group of drugs (barbiturates, or other CNS depressants). Notwithstanding, from this welter of disjointed information, three important inferences can be drawn:

1. Much of the known drug use problem occurs in drinking drivers.
2. A great variety of commonly prescribed, and over-the-counter drugs in combination with alcohol do potentially constitute a major traffic safety problem.
3. A broad research study which, at the core involves comprehensive toxicology analysis of biological samples from drivers, and includes selected, different demographic areas across the nation, is the only realistic way to determine if a significant problem exists.

This suggested definitive study could be based on analyses of samples from apparently intoxicated drivers who admit to drug use and/or whose blood alcohol concentration (BAC) is less than (say) 150 mg/100 ml. In general, the BAC of most arrested drinking-drivers falls between 180 - 240 mg/100 ml. Therefore, it would seem reasonable to assume that if the BAC is less than 150 mg/100 ml and the driver exhibits overt symptoms of intoxication, then an additional factor such as drugs may be involved, and a toxicology analysis worthwhile. Similarly, considering the well appreciated fact of drug prevalence, use and abuse, in society today, it is reasonable to expect forensic toxicologists involved in "Drinking Driver Programs" to be capable of analyzing biological samples for other drugs, and expressing an opinion as to the meaning of the analytical results in terms of driver impairment.

Unfortunately, until very recently there has been a "Catch 22" trap. The technical capability required to analyze small blood samples for a realistic range of common drugs and their metabolites has not been available and, except in the most gross circumstances, toxicological knowledge to support interpretation of the analysis is uncertain and scarce. The toxicological knowledge cannot be acquired until the analytical capability is available; and in most Government Toxicology Laboratories the cost, time and effort of becoming analytically proficient cannot be justified until a real problem has been defined. There are two breaks in this vicious circle which can now be exploited: a) analytical capability sufficient in sensitivity, specificity and quantitative accuracy in the form of gas chromatography-mass spectrometry (and immunological methods for sensitive screening purposes) and b) the many scientific reports documenting widespread drug abuse. These breaks provide a rational basis for service laboratories to become involved.

GC-MS coupled to a data system or computer is the only method which can provide a legally tenable analysis of a blood sample for a broad range of drugs, rapidly and specifically. It should be realized that it is not a panacea and there is still no ideal method for the detection of either cannabinoids or LSD in circulatory system samples. In general, drugs which are chemically weak acids or neutral occur in micrograms/milliliter concentrations and are not difficult to assay by common techniques, but basic drugs which are the largest group, and include common tranquillizers, stimulants and psychoactive agents occur at nanograms/milliliter and less, and require GC-MS techniques.

The practical problems are many. It is noteworthy that those drugs which head the pharmaceutical industry sales tables, and are the most frequently prescribed, are also amongst the most difficult to detect and quantitate – namely the benzodiazepines Valium and Librium. Their almost willy-nilly use as medical panaceas for every visitor to a doctor's office with an itch or twitch of nervous tension has induced mass complacency in their potency, and yet these drugs can be pharmacological dynamite in combination with alcohol. Following therapeutic dosage the benzodiazepines occur in very low concentrations in blood and are extensively metabolized, often to another benzodiazepine drug (e.g. diazepam to oxazepam), which significantly complicates interpretation of the analysis. Thus, the most prevalent of drugs, ataxic muscle relaxants combined with a potent central nervous system depressant can cause dramatic motor function impairments, but they represent a very difficult analytical problem.

If a urine sample alone is available for analysis, only limited information can be obtained. The test result can only, at best, identify a drug and its metabolites. It cannot be inferred from a positive result that the detected drug exerted an effect at a particular time. It is simply evidence that at some unknown time the driver ingested the material. The urine constituents, not being a part of the active circulatory system cannot directly reflect physiological impairment. If the subject voided urine completely and then a urine sample was obtained for analysis approximately thirty minutes later at which time a drug was detected, it could be reliably accepted that the drug was in the circulatory system prior to the voiding.

These illustrative problems of sample choice, analytical difficulty and preliminary inferences from the analytical results, are just the thin edge of a very long wedge composed of pharmacological and physiological qualifications, and complexities that render interpretation of "under the influence of drugs" in any strict scientific sense quite impractical. The importance of dosage, time interval between dose and sample, pharmacodynamics of the drug; the subject's possible tolerance, hypersensitivity, liver function and metabolism are all factors to convince the perplexed toxicologist of the impossibility of his task. Fortunately as Mr. Bumble reminded us, "the law is a ass". It pays no respect to absolutes of science, and reserves the right to be arbitrary. Application of law and forensic science must primarily be reasonable and therefore, just as unreasonable BACs (in excess of 80 or 100 mg/100 ml) are not permitted by statute, so a legal Plimsoll line for drugs must be decided.

If the range of maximum blood concentrations for a variety of drugs ingested under therapeutic conditions were known, then these data (or some multiple of the therapeutic concentration range) could be used to define and arbitrate the legal interpretation of analytical results for "driving under the influence" purposes. Such a compendium of data is not available today but various independent workers and groups have attempted the labor of compiling information from the literature and personal experience; and clinical research data are increasingly developed by pharmaceutical manufacturers. The task may not be as overwhelming as it appears if existing knowledge were used as a base and additional drugs were studied logically, with those of common availability and known hazard potential to drivers studied first. This program might well be sponsored in the U.S.A. by the Department of Transportation, through the National Safety Council, Committee on Alcohol and Drugs. It would be mandatory, of course, that special project research, typically Blomberg and Presser's methadone study (1), Woodhouse's marijuana work (6), and most importantly Forney's alcohol-drug interaction program (2, 3, 4) be continued in order to build an intelligence bank on which to base opinion concerning automobile driving.

SUMMARY AND CONCLUSIONS

The thesis of this paper is simple. The laboratory tools and the social justification are available for the first time to study and force the real drugged driver to stand up. A method and rationale by which this can be accomplished has been outlined, and reasonable law enforcement achieved. But, the point at issue is: can the time, labor and tax dollars which are required to catch a glimpse of the quarry be justified by the possible benefits in future traffic safety?

Judging from experience with the drinking driver (we pictorially understand him exceedingly well and he is prosecuted with zeal and vigor but his dastardly activity has been little diminished over the years) the answer must be NO. By contrast, the simple adjustment of the maximum speed limit to 55 mph in the United States appears to have wrought a minor miracle in reduction of vehicle accidents. Do priorities and practicalities then, dictate that the drugged driver be left quietly to smoulder? Surely not. Increasing numbers of vehicles are on the highways each year and more people are driving; particularly young people. Concurrently, more persons are taking drugs for real or imagined reasons (to go to sleep, to stay awake and for everything in between). The importance of alcohol-drug combinations is increasingly appreciated, and the significance of alcohol in traffic safety is well accepted.

However, of over-riding importance is the necessity for the general, driving public (and the medical and pharmacy professions) to recognize the risks associated with uncontrolled drug use, particularly in conjunction with alcohol, and have a basis for personal decision. It is for this principal reason, that the drugged driver and his influence on the highway must be identified and placed in proper perspective.

REFERENCES

1. Blomberg, R. D. and Preusser, D. F., *Drug Abuse And Driving Performance.* U.S. Department of Transportation, NHTSA Report, 1972. Contract Number DOT-HS-099-1-184.

2. Forney, R. B. and Hughes, F. W., *Combined Effects of Alcohol And Other Drugs.* Charles C. Thomas, Springfield, Illinois, 1968.

3. Forney, R. B., The Interaction of Other Drugs, Including Psychomimetics. *Drug Information Journal,* Jan/June (1972).

4. Forney, R. B. and Richards, A. B., *Ethanol, Other Chemicals And Their Potential*

Combinations Which May Influence Automobile Driving Performance. Report To U.S. National Safety Council, 1974.

5. Kibrick, E. and Smart, R. G., Psychotropic Drug Use And Driving Risk: A Review And Analysis. *Journal of Safety Research* 2, 73-85 (1970).

6. Milner, G., *Drugs And Driving* Vol. 1 S. Karger, Basel, 1972, pp 1-123.

7. Nichols, J. L., *Drug Use And Highway Safety: A Review of The Literature.* U.S. Department of Transportation. NHTSA Technical Report 1971. Contract Number DOT-HS-800-580.

8. Perrine, M. W., *Alcohol, Drugs And Driving.* U.S. Department of Transportation Report 1974. Contract Number DOT-HS-801-096.

Immunoassays for the Detection of Drugs in Drivers

Robert Forney, Jr., and Irving Sunshine,[1,2]

Many procedures are currently in use for the detection of drugs in biological fluids. These include gas-liquid chromatography (1), thin-layer chromatography (7), fluorometry (3), and spectrometry (2). Since many drugs are effective in small amounts, the amount present in biological specimens following ingestion may be in low concentrations. Hence sensitive analytical techniques must be employed. Most frequently separation and concentration procedures are utilized as well to complete the analysis successfully. The combination of the need for many programs of sensitive and extensive analysis with the tremendous volume of samples to be analyzed brought about the development of the immunoassay.

Immunoassay provides chemists with a new approach to drug analysis (4, 5). Developed in 1970, immunoassay of drugs is sensitive, reliable and can provide the means of handling extremely large volumes of samples at a very nominal cost. First used for the measurement of insulin in serum (8), the technique is based on the binding of a specific drug by an antibody in much the same manner as bacterial antigens are bound by antibodies in the immune-response in man. In order to facilitate the assay, the drug of interest is labeled and attached to the antibody. When the sample is added, the unlabeled drug present in the sample will competitively displace the labeled drug from the antibody complex. The concentration of the drug in the sample can then be determined by measuring the amount of displaced labeled drug or, alternatively, by measuring the amount of labeled drug still bound to the antibody.

Antibodies capable of binding drugs do not occur naturally and must be produced. Drug molecules, by themselves, are too small to be antigenic, so the first step in the preparation of a drug antibody is to attach the drug to a protein. This drug-protein complex is a good antigen and when injected into an animal produces antibodies directed against various portions of the drug-protein complex. The antibodies which recognize the drug portion of the complex are then isolated from the animal's serum and can be used to assay for the drug. These antibodies have a high affinity for the drug and are reasonably specific. Only molecules of closely related chemical structures interfere significantly. Because of the high sensitivity and great specificity of the immunoassay, it may be performed without the usual extraction and concentration steps.

[1] Institute of Pathology, Case Western Reserve University, Cleveland, Ohio 44106, U.S.A.

[2] This project was supported in part by funds received from the National Institute on Drug Abuse for grant – No. DA 00990-01.

Four different immunological assay systems for drugs of abuse are now available commercially: 1) Free Radical Assay Technique (FRAT); 2) Enzyme Multiplied Immunoassay Technique (EMIT); 3) Radioimmunoassay (RIA) and, 4) Hemagglutination Inhibition (HI).[3]

The first major application of the immunoassay to the analysis of drugs was the FRAT system. In this procedure, a stable free radical, a nitroxide, is attached to morphine. The free radical contains unpaired electrons which may be observed and measured by an electron spin resonance (ESR) spectrometer. This instrument measures the energy absorbed by unpaired electrons as they flip from a stable to a metastable position in a magnetic field.

While the FRAT system was developed for the detection of morphine, it has also been successfully applied to the analysis of methadone, barbiturates and amphetamine. The technique is simple to use, rapid (one sample per minute) and objective, needing just the measurement of the recorded response. The basic equipment it requires is very expensive, $25,000. The reagents required cost 50 to 60 cents per test. The FRAT procedure finds it application, therefore, only in laboratories where a large number of samples – 1000 or more a day – are routine. As with all immunoassays, a positive result by this technique is equivocal and needs corroboration. However, a negative result is definitive. While the detection sensitivity of the FRAT procedure is not the highest available, it is more than adequate for most applications.

The same group that developed the FRAT also went on to develop the enzyme multiplied immunoassay technique, or EMIT. In this assay procedure, the label attached to the drug is an active enzyme, lysozyme. This enzyme catalyzes the hydrolysis of the mucopolysacharide component of the cell-wall of certain types of bacteria. The enzyme-labeled drug is then bound to an antibody against the drug which renders the enzyme inactive. In the analytical application, some of the enzyme-labeled drug is displaced from the antibody by any similar drug present in the sample. Displaced from the antibody, the enzyme is re-activated. The activity of the released enzyme on the substrate is correlated to the concentration of the drug present and can be measured by observing the rate of clearing of a turbid suspension of bacterial cell walls as the enzyme hydrolyses them into small soluble pieces. This results in a decrease in the absorbance of the test mixture. Three measurements are needed to observe this: the initial and final absorbances and the time interval between them. Instruments which do this automatically are commercially available.

The EMIT procedure takes one minute to complete, is simple to perform and is applicable to many drugs – morphine, methadone, amphetamine, barbiturates and the metabolite of cocaine, benzoyl ecgonine. Its primary advantage over the FRAT procedure is the moderate cost of the equipment: $6,000. The reagents required for each test are comparable in cost to those of other immunoassay systems, about 50 cents. The EMIT system, as originally developed, was only applicable to urine samples. However, a recent development, utilizing a different enzyme, glucose-6-phosphate dehydrogenase, enables the analysis of serum as well as urine for phenobarbital and dilantin (6).

A third type of immunoassay is the radioimmunoassay or, RIA. RIA employs a drug which has been labeled with a radioactive isotope, such as ^{3}H, ^{14}C, or ^{125}I. In this procedure, competitive displacement takes place between the labeled drug and the drug in the sample. Then the labeled drug displaced from the antibody must be separated from the antibody-bound labeled drug. This is achieved by precipitating the entire antibody pool (including free antibody, antibody-drug and antibody-labeled drug complexes) with ammonium sulfate. The supernatant will contain the unbound labeled drug which may be measured by determining the radioactivity of the solution using liquid scintillation spectrometry or gamma-radiation counting, depending on which label is used.

---

[3] "FRAT" and "EMIT" are registered tradenames, products of SYVA Corp., Palo Alto, Calif., "ABUSCREEN" of Hoffmann-LaRoche, Nutley, N.J., and "HI-M" of R.D. Products, Inc., Victor, N.Y.

The advantage of the RIA technique is that, because the radioactively labeled drug has a high specific radioactivity, its concentration can be determined with great sensitivity and precision. In fact, when quantitative data are desired, most samples usually have to be diluted because the standard curve has a limited linear range. One advantage of RIA over FRAT and EMIT is that it is applicable to serum as well as to urine specimens.

The objections to the RIA technique arise principally from the nature of the isotope employed. The shelf-life of the reagents is relatively short and safety precautions must be observed while working with the isotope. Also, the time for one determination is relatively long, approximately 40 minutes. When many samples are analyzed together, however, the time per sample decreases significantly.

Hemagglutination inhibition is the most inexpensive of all the immunoassay techniques. It requires no elaborate equipment. Several molecules of the drug of interest are attached to each of the red blood cells in a suspension which has been stabilized with formaldehyde. Antibodies are bivalent, that is, they each have two binding sites. When the antibody is added to the suspension, many of the blood cells will be bound together and agglutination occurs. If sufficient free drug (from the test sample) is added to saturate the antibody binding sites, the red blood cells will not be cross-linked and agglutination will not occur (inhibition of agglutination). When agglutination occurs the suspension of red blood cells appears cloudy with a diffuse red background. When drug is present in the sample and agglutination is inhibited, the red blood cells form a sharp pellet with a clear supernatant. This procedure normally provides only semiquantitative results and is not as sensitive as the other immunoassay techniques. It is slow when single analyses are performed, since the cells must settle one and one half to three hours before clear pellet formation can be observed in positive samples. When a large number of samples are to be analyzed simultaneously the time per sample becomes comparable to the other immunoassays. Thus it can be practical when a large number of samples are being processed and semi-quantitative results are sufficient.

Taken as a group, the most serious limitation of immunoassays is that specificity for a drug is not absolute and drugs of a similar chemical structure may cross-react. This means that all positive results must be confirmed by some other procedure. Although it is true that any chemical analysis performed has the same limitation, because of the immunoassay's high sensitivity, all positive results must be confirmed. The immunoassays have very much to recommend them. They are sensitive, accurate techniques and make possible the analysis of large numbers of specimens on a routine basis.

Two of the immunoassay procedures, RIA and EMIT, were applied to the analysis of one hundred urine samples obtained from the Cleveland City Police Department. The samples were those collected from drivers who were suspected of driving while under the influence of alcohol. EMIT and RIA were both employed for the determination of the presence or absence of morphine, methadone, amphetamine and barbiturates. In addition, the EMIT system was used to examine the urines for the presence of benzoyl ecgonine. All positive results were retested by either gas chromatography or fluorometry. The results of this study are presented in Tables I and II.

TABLE I *Summary of Urine Analyses*[a]

Drug	EMIT	RIA	Confirmation
Morphine	0	1	0
Methadone	0	0	–
Amphetamine	3	2	2
Barbiturates	6	6	5
Benzoyl Ecgonine	0	–	–
TOTAL	9	9	8

[a]The total number of samples found to be positive for each drug by each assay are shown. A total of one hundred urines were analyzed for each of the drugs listed. The determination of benzoyl ecgonine was done by EMIT only.

TABLE II *Results of Urine Analyses*

Sample	Drug Found	EMIT µg/ml	RIA µg/ml	Confirmation
25575	Morphine	negative	0.035	negative (F[a])
25575	Methamphetamine	4.0	0.031	Methamphet. (GLC[b])
25611	Amphetamine	0.6	0.680	Amphet. (GLC)
25524	Amphetamine	4.0	7.000	Amphet. (GLC)
25611	Amobarbital	±	>0.600	1.0 (GLC)
25613	Barbiturate	0.3	0.088	negative (GLC)
25513	Phenobarbital	4.5	>0.600	6.0 (GLC)
25581	Phenobarbital	4.0	>0.600	8.0 (GLC)
25596	Phenobarbital	2.2	0.225	2.0 (GLC)
707	Phenobarbital	15.0	>0.600	25.0 (GLC)

[a]F fluorometry

[b]GLC gas-liquid chromatography

One urine (25575) educed a response for morphine by RIA. The theoretical concentration of the morphine found in the sample was well below the detection limit of the assay. Fluorometry failed to confirm the presence of morphine and the sample was reported negative for morphine.

The sample which was positive for morphine by RIA (25575) gave a positive EMIT reaction for amphetamine (4.0 μg/ml) but a negative amphetamine reaction by RIA (0.031 μg/ml). This discrepancy was resolved by gas chromatographic analysis which indicated the sample contained methamphetamine. This is consistent with the known specificity of RIA for amphetamine and the lack of this specificity in the EMIT procedure.

Both of the above mentioned examples illustrate the necessity of the confirmation of positive results and of a careful examination of the data and interpretation of the results.

Two other samples found to contain amphetamine by immunoassay were confirmed by gas chromatographic analysis.

Six of the urines were positive for barbiturate by both EMIT and RIA. One of these (25613) was found in a concentration below the detection limit of the gas chromatographic procedure (1.0 μg/ml) and was reported as negative for barbiturate because it could not be confirmed. The other five were confirmed and specifically identified by gas chromatography.

Immunological assays are a valuable addition to the analytical armamentarium for the detection of drugs of abuse in biological systems. The high sensitivity and specificity which immunoassays provide eliminate the need for prior extraction and concentration of drug from the sample. Radio-immunoassay is the most sensitive of the assay techniques and can be used to obtain quantitative results by diluting positive samples. If the capability of performing rapid single sample analyses is required, two systems, FRAT and EMIT, are available. Both provide good sensitivity and precision. The hemagglutination inhibition assay can be employed at a very low cost for capital equipment. Each immunoassay, therefore, has its own advantages and limitations. The particular method best suited for application in any particular institution is determined by the number of samples to be analyzed per day, the sensitivity and accuracy needed, turn-around time requirements as well as money available for hardware and reagents. In an immunoassay, few things can produce a false negative result. Immunoassays can save a great deal of time in situations where a large percentage of all samples are negative. However, those samples indicated to be positive require further analysis using non-immunological methods such as thin-layer chromatography, gas-liquid chromatography, fluorometry or spectrometry.

REFERENCES

1. Finkle, B. S., Cherry, E. J. and Taylor, D. M., GLC Systems for the detection of drugs. *Journal of Chromatographic Science* 9, 393 (1971).
2. Kananen, G., Osiewicz, R. and Sunshine, I., Barbiturate Anayasis – A Current Assessment. *Journal of Chromatographic Science* 10, 283 (1972).
3. Mulé, S. J., Methods for the Analysis of Narcotic Analgesics and Amphetamines. *Journal of Chromatographic Science* 10, 275 (1972).
4. Mulé, S. J., Bastos, M. L. and Jukofsky, D., Evaluation of Immunoassay Methods for Detection, in Urine, of Drugs Subject to Abuse. *Clinical Chemist* 20, 243 (1974).
5. Mulé, S. J., Sunshine, I., Braude, M. and Willette, R. E. (eds), *Immunoassays for Drugs Subject to Abuse*, CRC Press, Cleveland, Ohio, 1974.
6. Pippenger, C. E., Sichler, D. L. and Lichtblau, L., Preliminary Clinical Evaluation of an Experimental Enzyme Immunoassay System for DPH and Phenobarbital in Serum. *Clinical Chemist* 20, 869 (Abs. #076) (1974).
7. Sunshine, I. (ed.), *Handbook of Analytical Toxicology*, Chemical Rubber Company, Cleveland, Ohio, 1969.
8. Yalow, R. S. and Berson, S. A., Assay of Plasma Insulin in Human Subjects by Immunological Methods. *Nature* 184, 1648 (1959).

A System for Breath Alcohol Analysis, and a System to Collect and Preserve Breath Evidence of Blood Intoxicants

Wallace E. VanNote[1] and Naresh C. Jain

THE PRESERVIAL(R)

This is a preliminary report describing an inexpensive, simple to use, self-sealing system for breath analysis called a Preservial(R). It was developed to meet the court requirements for alcohol/breath test evidence, since several States require police officials to keep the breath analysis evidence and make it available to the defence.

The Preservial consists of an optically clear seal flange glass vial, a teflon-lined rubber septum, and aluminium sealing ring or screw cap. The vial shown in Figure 1 is a 16.5 mm O.D. spectral grade glass of a size to hold 3.0 ml of acid-dichromate solution containing an appropriate catalyst (e.g. silver nitrate) to a depth of 17 mm. The septum is then secured to the vial with the aluminium seal so that the test medium (acid-dichromate) is free from outside contact. Next, the needle-cannula (the bubbler-exhaust) assembly is inserted through the septum (Figure 1.). The 19ga needle, or bubbler, is 1.5 inches long and extends halfway down into the solution. The cannula, or exhaust, is 0.3 inches long and remains well above the surface of the test medium. The breath sample is introduced through the needle into the test solution. The uniform diameter of this bubbler-needle has the advantage over glass bubblers of irregular orifice size of enabling one to predict quantitive (rate-reaction) results.

After analysis, the needle-cannula assembly is removed, allowing the septum (or stopper) to self-seal so that reactant materials can be stored in the airtight Preservial.

Under experimental conditions, the prefilled Preservial upon inverted storage has shown no reaction or change in solution quality. Experiments are under way to determine preservation effects due to post-analysis interference or contamination of non-alcoholic aerosols and teflon-rubber seals. For example, a series of partially reacted test solutions were prepared from 0.10 to 0.30% BAC simulator solutions and packaged in teflon-sealed vials. For the past two months, there has been no change in these sample readings, suggesting that preservation is possible.

Thus this Preservial has the unique improvement of simplified evidence storage, unlike existing evidential test ampules which have little or no way of being successfully

---

(R)(Patent Pending) Omicron Systems Corporation

[1] Omicron Systems Corporation, Palo Alto, California 94303

sealed and retained as courtroom evidence. Police officials are currently using breath analyzers as evidence employing acid-dichromate ampules because they are required in several States to keep breath analysis samples available for the defence.

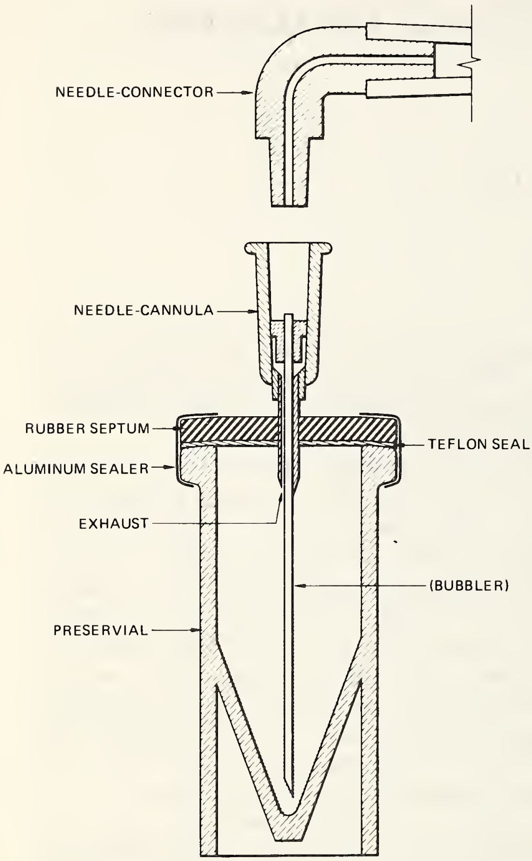


Figure 1 *Micro Conical Preservial Breath Volatile Intoxican Collection and Preservation.*

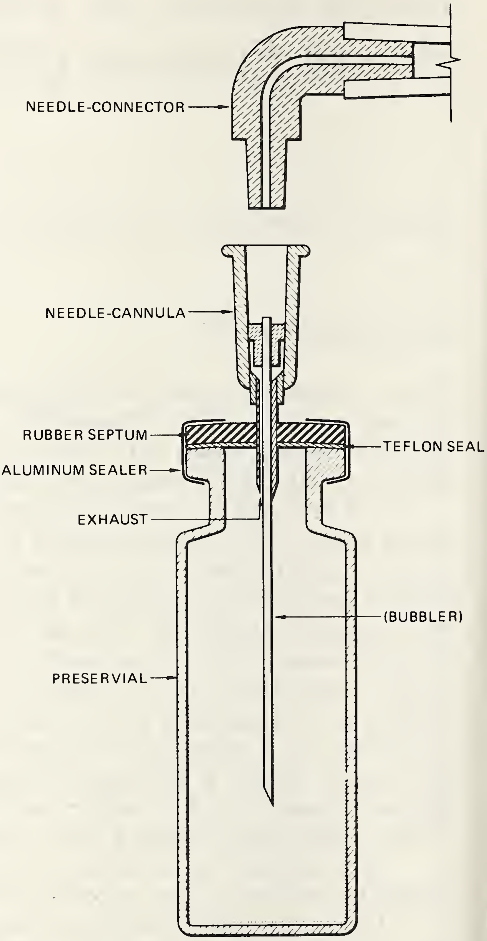


Figure 2 *Acid-Dichromate Preservial with Needle-Cannula Assembly for Breath Alcohol Analysis.*

THE CO-SWEEP PRESERVIAL

This is a micro-container which is an extension of the needle-cannula concept and is used to collect, concentrate and preserve intoxicants such as alcohol, acetone and the cannabinoids from breath samples.

The principle, similar to that used in fraction collection of gaseous compounds, recondenses breath volatiles. This liquid medium method is a more ideal system than either the solid absorption techniques which have unpredictable recovery rates, or the gaseous collection system whose vapor storage containers have both uncontrolled absorption and leakage. The Co-Sweep Preservial has a dynamic concentrating feature, a small containment area, and minimal analysis preparation. Principal parts of the Co-Sweep sampling device are shown in Figure 3.

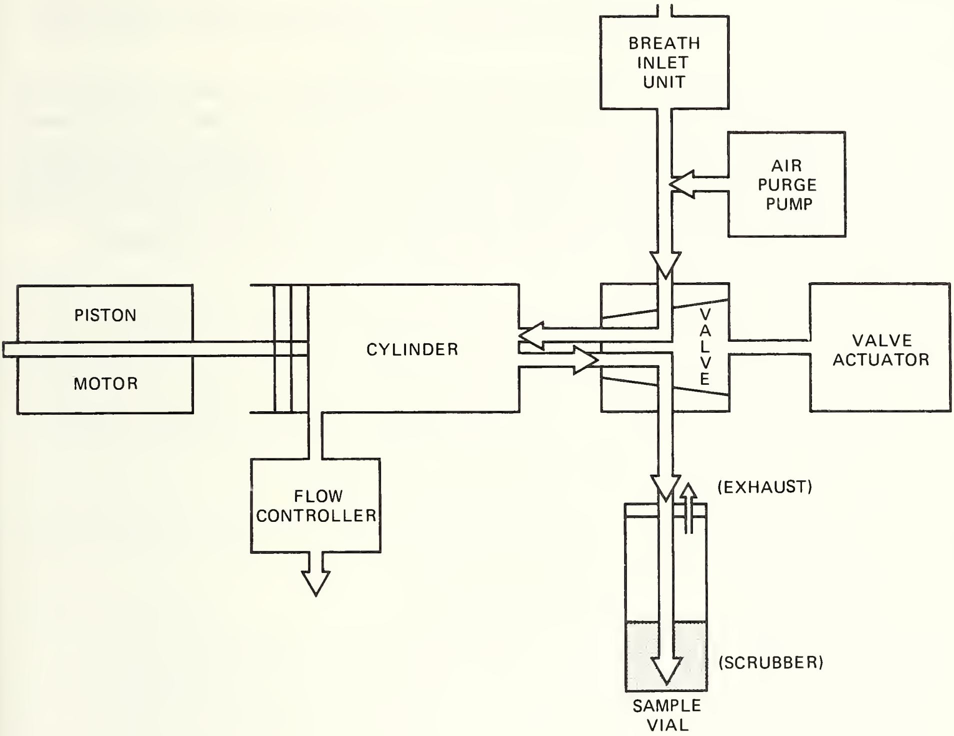


Figure 3 *Co-Sweep Collection Unit.*

The vial (Figure 2) is 16 mm O.D. and 45 mm long. The conical portion has a volume of 0.3 ml, and the total vial volume is approximately 2.3 ml. The package volume will depend on the particular application. For breath alcohol collection, the aqueous liquid volume will vary between 0.1 ml – 1.0 ml. A teflon-lined rubber septum (20 mm) is fixed to the Preservial and sealed with an aluminium crimp seal to secure the vial for future sampled introduction. The whole Preservial is made of a rugged inert plastic, such as polystyrene or polypropylene, to prevent sample interference.

The shape and size can vary depending on the purpose: the Co-Sweep Preservials are designed for direct use in spectrophotometry or for analysis that uses virtually any laboratory technique or instrument.

For gas chromatographic analysis, appropriate internal standards such as methylethyl ketone or acelonitride, as well as a preservative such as Na F can be used – impossible in solid absorption and gaseous collection systems. Expected shelf life of the Preservial will be dictated by the type of internal standard and preservative.

The Co-Sweep Preservial is still under study to determine correct bubble size (flow rates) sample size, correlations or recovery rates and storageability. Also under study is further application of the Preservial concept to breath samples. These include the test for acetone in breath of diabetics, industrial solvents and aerosol in workers, cannabinoids in marijuana and hashish smokers and volatile solvents in glue sniffers.

SUMMARY

The Co-Sweep Preservial collection and preservation systems have been developed for sampling and evidence retention of breath volatile intoxicants in drunken driver cases. This system provides for both local and field sampling, in conjunction with health analyzers. It provides a low cost and easy to operate method of sampling and retaining samples. Finally, it has the added feature that any laboratory can analyze the liquid sample using gas chromatographic, enzymatic or spectrophotometric techniques.

A Simple Method for the Determination of the Smoking of Marijuana

Lawrence C. Kier[1]

The widespread usage of marijuana as a drug of abuse has been well documented. A simple inexpensive, rapid method for its detection is therefore desirable. A personal communication from Curry[2] indicated that it might be feasible to determine the presence of marijuana on chloroform-washed fingers or lips of persons alleged to have handled or smoked cannabis. The following method for sample collecting and analysis was first presented at the Wyoming Trauma Conference in September 1971.

MATERIALS REQUIRED

For Collection

1. Wooden-handled cotton-tipped swabs ("Cotton buds Johnson & Johnson").
2. Isopropyl Alcohol (2-propanol) (J. T. Baker #1-9084).
3. Plastic Dropper bottles with screw caps.
4. Polyethylene bags, 3 x 5 inches in size, divided into three compartments by heat-seal.

For Extraction

1. Methanol (J. T. Baker).
2. Tubes 16 x 100. Disposable culture tubes.
3. Dri-Bath Thermoline Dubuque, Iowa or boiling water bath.
4. Silent Giant or other air source.

For Thin Layer Chromatography (TLC)

1. 6 ounce juice glasses.
2. Clear plastic wrap (stretch & Seal R) or equivalent.
3. Baker-Flex (R) Silica Gel 1B 2-F 1x3 inch (7.5 x 2.5 cm) (J. T. Baker) stable six months in heat sealed plastic envelopes.

---

[1] Kier Laboratories Inc., 6740 E. Hampden Ave., #303, Denver, Colorado 8022, U.S.A.
[2] A. S. Curry, Director of the Central Research Establishment, Reading, Berkshire, England.

4. Diethylamine (J. T. Baker #9216).
5. Benzene (J. T. Baker #9154).
6. Fast Blue 2B Salt (National Biological Stains Dept., P.O. Box 431, Morristown, N.J. 07960).
7. Stain – 0.1% of #6 in 33% methanol (stable 4 hours).
8. Standard Δ9THC in ethanol (U.S.P.C. Inc., Rockyville, M.D.)
   Dilute 1:10 in ethanol spot 2 microliters (may be pre-spotted on 3 and then heat-sealed).

MARIJUANA TESTING

The quality controlled kit described above is used to demonstrate whether an individual (living or deceased) has been smoking marijuana in some period of time prior to the sampling and to protect the chain of evidence until the analysis is completed.

Upon removing the paper seal (evidence the kit has not been tampered with) one finds a plastic envelope divided into three compartments labeled: a) lips, b) right hand, c) left hand; a plastic vial containing isopropyl alcohol; and an address label.

Collection Method

Several drops of solution are placed in the plastic vial on the cotton on the end of the applicator stick; using a scrubbing motion and rotation of tip. The lips (upper) are scrubbed and the applicator is placed back in the appropriate slot. This is repeated with appropriate swabs on the inner side of thumb and finger and finger tips closest to smoke from marijuana cigarette even if a crutch is used.

Extraction Technique

The wooden handled cotton swabs are removed from plastic envelopes and placed in an appropriately labeled 16 x 100 mm disposable culture tube containing 2 ml of methanol. The methanol is heated to its boiling point in an electric test tube heater or boiling water bath. As soon as the methanol comes to a boil the swab is taken out and excess solvent is removed by squeezing and rolling the cotton tip against the side of the tube. Completeness of removal can be checked by testing the extracted swab with the fast 2B salt stain. The solvent is evaporated to dryness with a stream of forced air.

TLC

The residue is dissolved in 10 microliters of methanol, mixed on a micro mixer for 31 seconds. The total amount is removed and spotted on a Silica Gel microscope slide. The TLC strip is impregnated beforehand with diethylamine and prespotted with 2 microliters of standard Δ9THC 7 mm from the bottom of the strip and 10 mm from the left side. The lip extract is run first and spotted 7 mm from the bottom of the strip and 11 mm from the right side. They are then placed in a 6 ounce juice glass containing 3 cc of benzene which acts as a developing solvent. The strips are triple developed. The solvent is allowed to migrate one-third of the distance (2.5 cm). The Silica Gel strip is then removed and allowed to dry. The solvent is allowed to migrate to two-thirds the height of the strip and is then removed and dried again. The final development is to 7 cm.

The Color Development

The TLC strip is then allowed to air dry and is stained by daubing the Fast 2B solution with a cotton ball applicator. A rose pink spot on the lip side compared to the standard (0.6 RF) is a positive test. If the lips are positive, run the right and left hand.

Developmental

The areas selected for extraction were determined with the cooperation of the Jefferson County, Colorado, and Denver County, Colorado coroners offices. Twenty deceased individuals were, because of appearance, dress, and associated materials at the scene (for example, marijuana) selected for sampling. The sites sampled on these individuals were the nose, throat, gums, fingers, upper and lower lips. The areas giving the best response by TLC were the upper lips and the thumb and forefinger of the dominant hand. The other hand acted as a control.

In response to an inquiry at the Fourth International Meeting of Accident Prevention in Paris, we evaluated the recovery from time of collection until time of testing. There was no decrease in recovery up to and including ten days.

This technique is sensitive down to 0.5 mg of either Δ8 or Δ9THC. For our recovery studies on the upper lips, volunteers were tested who had smoked 1 gm of "good grass". They were tested at various time intervals immediately after smoking, 6 hours, 12 hours, and 24 hours after smoking. Only the immediate and 6-hour interval gave positive results.

The upper lips (area under nose) on five subjects were 'spotted' with 30 μg of Δ9THC and sampled at 1, 2, and 4 hours. The collection technique was carried out as above utilizing one-third of the residue for TLC (equivalent to an original concentration of 10 μg Δ9THC). All subjects tested were positive at all times. The results were: one hour – 75% recovery, two hours – 50% recovery, and four hours – 10% recovery. The one exception to this was a male subject with a mustache who showed a 50% recovery at four hours.

Thus, an ideal positive test is when the lips are positive for at least 0.5 μg Δ9THC and a trace of Δ9THC is found on dominant hand, with none detected on the other hand. Individuals who have been in an environment with high concentrations of marijuana in smoke at a "pot party" but who claimed they had not smoked, demonstrated positive tests on lips, right and left hands – all of equal intensity.

The law enforcement agents were trained to collect samples either by video tape training film or by printed instructions. Initial test subjects were preselected on the basis of age, appearance, (hippie type) and the presence of marijuana upon the person.

To utilize the procedures for drugs of abuse including marijuana, 47 consecutive admissions to the emergency room of Denver General Hospital who were suffering trauma from single incident motor vehicle accidents, stabbing and gunshot wounds were examined. The samples were collected by resident physicians under the direction of Dr. Cleve Tremble (Table I and Table II).

The subjects were selected by them on the basis of erratic behavior with negative or low alcohols. The individuals were either charged with the operation of a motor vehicle under the influence of drugs or charged with the usage of drugs.

The coroners who had the greatest success (positive marijuana tests) were those who 'swabbed' immediately rather than waiting for a considerable time period (24-48 hours) when collecting samples during the autopsy. An example is of a 17-year old male who was drowned. His body was recovered after 30 minutes submersion. The

TABLE I *Non-Fatal Cases from Law Enforcement Agencies*

Drug	N	%
None found	25	54
Alcohol (>.05g/100 ml)	3	7
Marijuana	18	39
Opiates	1	2
Alcohol + other	1	2
Marijuana + Opiates	1	2

TABLE II *Non-Fatal Trauma Cases from Denver General Emergency Room*[a]

Variable	Motor Vehicle Accidents	Stab Wounds	Gunshot Wounds	Total
N	12	11	24	47
Male/Female	12/0	11/0	13/11	36/11
Black/White/Spanish	0/9/3	4/3/4	10/9/2	14/21/9
Average Age	26	29	28	27.7
Drug				
None found	0 (9%)	2 (18%)	1 (4%)	3 (6%)
Alcohol	6 (50%)	8 (73%)	11 (46%)	24 (51%)
Marijuana	5 (42%)	1 (9%)	11 (46%)	17 (36%)
Opiates	2 (17%)	6 (55%)	9 (38%)	17 (36%)
Alcohol + other	0 (0%)	5 (45%)	4 (17%)	9 (19%)
Marijuana + Opiates	1 (8%)	0 (0%)	4 (17$)	5 (11%)

[a]Source: Dr. Cleve Trimble and Staff, Denver General Hospital, Denver, Colorado.

marijuana test was positive. My summary impression is, however, that there appear to be fewer positive marijuana tests on the coroner's cases.

SUMMARY

A simple, rapid, inexpensive method for the determination of the smoking of marijuana is presented. The method of collection is simple enough for collection in the field by law enforcement agencies and the method of analysis is simple enough to be carried out in most laboratories.

The method will detect the smoking of marijuana up until at least 6 hours after smoking, depending on the strength of the marijuana and the technique of smoking.

Quality Control in a Toxicology Laboratory

B. M. Kapur[1] and L. McLaughlin

In clinical biochemistry laboratories, acceptance of the concept of quality control goes without saying, and for every conceivable test done there is a quality control procedure. There is a great deal of literature dealing with the problems of quality control in clinical biochemistry laboratories. The self-evaluation programme run by the Center for Disease Control, Atlanta, Georgia (4), was among the first to carry out an interlaboratory evaluation for drug quantitation. They showed the presence of discrepancies in quantitative barbiturate measurement. Larsen *et al* (3) provide another example of proficiency testing for drug screening.

QUALITATIVE ANALYSIS

Quality control in toxicology presents different problems to those found in clinical biochemistry. Thin layer chromatography, a widely used technique, involves subjective decisions in identifying drugs, especially when they are present in small quantities. There are also many variables which can influence the separation (Table I) and reproducibility (Table II) of thin layer chromatograms (1). Different parameters have to be kept under rigid control throughout the procedure.

An external quality control programme does have its merits. However, a big disadvantage is the delay in getting the results and 'on the spot' correction is therefore not possible. For on the spot checks, we devised a simple form which would allow us to monitor (a) the number of controls processed, (b) the number of these correctly identified, and (c) the other variables. Figure 1 shows a typical form used. The procedure was as follows.

With approximately every 10 patient urine samples, one spiked urine control was processed. On every thin layer plate there was a known aqueous standard and a urine control spotted. Approximately 40 thin layer plates were processed per day. As the laboratory is not a big one, and involves few people, monitoring different parameters was easily maintained. It was possible in this way to determine if there was a problem (a) with the operator or (b) a particular drug or (c) the thin layer chromatography operating conditions, e.g., spotting and running of the plate, spraying the plate, quality of spray, reagent, solvent preparation, and room temperature. Both unknown and blind controls were also processed as patient samples.

---

[1] Addiction Research Foundation, 33 Russell Street, Toronto, Ontario, M5S 2S1, Canada.

TABLE I *Factors that Cause Variation in TLC Separations (1)*

Technique	Equipment & Accessories
Sample work up	Sample applicators
Sample application	Quality of seals on chambers
Constancy of sequence of	Visualization sprays
Activation	Temperature control
Spotting	
Development	
Spray or visualization steps	
Read-out after visualization	

Physical-chemical

Residual moisture in adsorbent
Structure of adsorbent
Solvent viscosity
Solvent stability
Impurities in reagents
Sensitivity of separated compounds to visualization reagents.

Control Date____ to____ Month ______________ 197_

	Morphine	Codeine	Quinine	Methadone	d-Amphetamine	Methamphetamine	Amobarbital	Phenobarbital	Tech's Initials	Remarks*
Mon Spotted										
Seen										
Tue Spotted										
Seen										
Wed Spotted										
Seen										
Thur Spotted										
Seen										
Fri Spotted										
Seen										

**Considerations for Remarks* – Comments should be made, if (1) Room temp. was too high, (2) Separation was not good, (3) Solvent front not straight, (4) Quality of spray reagents was poor, (5) Any other comments.

Technician's Additional Comments	Supervisor's Comments

Figure 1 *A typical Toxicology Quality Control Form*

TABLE II *Effect of Major Variables on Reproducibility*[a] *(1)*

		Effect on	
Steps & Variables	Rf	Resolution	Quantitation
Layer preparation and use:			
a) Uniformity	+	+	+
Thickness	+	+	+
Activation	+	+	+
b) Composition	+	+	Indirectly
Sample application:			
a) Work-up	NA	D	+
b) Method of application	+	+	+
Capillary	+	+	+
Syringe	+	+	+
Streak	+	+	+
Chromatographic development:			
a) Solvent stability	+	+	+
b) Chamber characteristics	+	+	+
c) Solvent volume/flow rate	+	+	+
d) Temperature	+	+	+
Visualization:			
a) Ultraviolet	NA	NA	+
Absorption			+
Quench			+
Fluorescence			+
b) Visible	NA	D	+
Absorption		NA	+
Coloured		NA	+
Spray		+	+
Char		+	
Fluorescence		NA	
Quantitative read-out:			
a) Densitometry	NA	+	+
Reflectance			+
Ultraviolet		+[b]	+
Visible		+[b]	+
Transmission			
Ultraviolet		+[b]	+
Visible		+[b]	+
b) Radioactive techniques			+
c) Other			+

[a] Explanation of Table: + = affects parameter, NA = not applicable D = dependent on separation.

[b] Read-out by optical methods gives apparent resolving power, which is design-dependent.

By this procedure we were able to identify the source of several errors of which the following were the most common.

1. *Changed spotting techniques.* Because of the relatively large number of samples and the small amount of time in which to analyze them, thin layer spotting techniques

had been changed. 2. *Detection of morphine.* Morphine, in very small concentrations, takes a long time to appear after spraying with acidic iodoplatinate. The thin layer plate should be left for approximately one hour after spraying before interpretation. However we found that morphine was being interpreted too early, causing a number of errors to be made. 3. *Incorrectly prepared solvents.* 4. *Solvent tanks that were left open.* 5. *Quality of reagents.* 6. *Insufficient time lapse between sprays.*

Correlating identified samples with the number spotted, variations in percentage accuracy were calculated. By using the above method identification of morphine improved from 89% to 96%.

QUANTITATIVE ANALYSIS

Quantitative toxicology differs from qualitative toxicology in that the interpretations are not subjective. However, many problems arise due to the different assay techniques. Barbiturates, for example, can be done by colourimetric, ultra violet, and gas chromatographic (GC) techniques. For each of these methods there is a variation in sample preparation. Since there is not much automation, samples are processed individually, thus changing the error from sample to sample. The self-evaluation programme of the Center for Disease Control (4) showed a wide range of results in the barbiturate quantitation, reflecting both the method variation and inter-laboratory variation. Tables III and IV show "all methods means" for secobarbital and phenobarbital. Participating laboratories were divided into four groups – Public Health Laboratories, Forensic Laboratories, Private Laboratories and Hospital Laboratories. The "all methods mean" for secobarbital was 4.5 mg/100 ml, the target value was 5 mg/100 ml. For phenobarbital the "all methods mean" for 78 different laboratories was 15.7 mg/100 ml as opposed to the target value of 20 mg/100 ml. The ranges for each group for both secobarbital and phenobarbital were wide.

TABLE III *Results of Secobarbital Analysis (4), (target value 20 mg/100 ml.) All Methods Mean[a] for Four Laboratory Groups.*

Laboratory Groups Surveyed	Mean (mg/100 ml)	n[b]	Range (mg/100 ml)
Public Health	5.02	8	2.4- 8.8
Forensic	4.13	7	2.9- 8.2
Private	3.90	23	1.0- 8.4
Hospital	5.06	33	0.8-12.0
TOTAL		71	
AVERAGE	4.59		

[a] Ultra violet and gas chromatrographic

[b] Number of laboratories which participated

For sample preparation of the GC technique the calculations and conditions have to be monitored very carefully. The internal standard used for the procedure has

TABLE IV *Results of Phenobarbital Analysis (4), (Target Value 20 mg/100 ml.) All Methods Mean[a] for Four Laboratory Groups.*

Laboratory Group Surveyed	Mean (mg/100 ml)	n[b]	Range (mg/100 ml)
Public Health	15.17	11	6.1-26.9
Forensic	17.22	8	3.2-32.7
Private	14.47	25	1.6-23.6
Hospital	16.41	34	2.7-30.0
TOTAL		78	
AVERAGE	15.69		

[a] Ultra violet and gas chromatographic

[b] Number of laboratories which participated

Clinical Institute
Addiction Research Foundation
DRUG SCREENING – URINE OR GASTRIC

PATIENT IDENTIFICATION

N.S.Q. – Not sufficient quantity
N.S.R. – New specimen required
I.S. – Improper specimen
U – Unlabelled specimen
* – Corrected result

– = Not detected
+ = Positive
Q = Questionable

PAGE ( )

DATE TIME										
Specimen LAB. #										
Amphetamine										
Methamphetamine										
Barbiturate										
Morphine (Heroin)										
Codeine										
Quinine										
Methadone										
Phenothiazines										

DONE BY/CHECKED BY

DATE

COMMENTS

Figure 2 *Sequential Reporting Form for Drug Screening–Urine or Gastric*

a great bearing on the quantitation. The point of introduction of the internal standard into the sample, and its retention time as compared to the drug being quantitated, are of great importance. The internal standard should preferably be of similar chemical structure, ideally the same compound.

A few manufacturers have made quality control lypholised sera available; however these are very expensive. Pooled drug-free sera can be used and drugs added to give a known final concentration. In our experience, when individual drugs are added to these sera pools, they are stable for a long time (at least 6 months) when kept at −15°C.

GC conditions and operator techniques should be monitored. To monitor the GC conditions we tabulated retention times of reference compounds on a daily basis on a form from which one month's data could be seen at a glance. Reviewing this, the different gas chromatographic conditions, e.g., the column conditions, gas flow rate, temperature changes, column packing conditions, and electronic functions of the system, could be easily monitored.

By processing standards, quality control sera and split samples, we were able to monitor the extraction and quantitation, tabulation of results, and the operator and his techniques. This allowed interjection wherever action was necessary. Errors corrected in this way were (a) inconsistency in extraction methods, (b) mis-identification, and (c) calculation errors.

PATIENT
IDENTIFICATION

Clinical Institute
Addiction Research Foundation
DRUG SCREEN – BLOOD

N.S.Q. – Not sufficient quantity
N.S.R. – New sample required
I.S. – Improper sample
U – Unlabelled specimen
H – Hemolysed

* = Corrected report
– = Not detected

PAGE (   )

		DATE TIME										
SEDATIVES	Amobarb	mg/1										
	Secobarb	mg/1										
	Phenobarb	mg/1										
	Methyprylon	mg/1										
VOLATILES	Ethanol	mg/1										
OTHER	Salicylates	mg/1										
CHECKED BY												

Figure 3 *Sequential Reporting Form for Drug Screening–Blood*

Finally, a sequential reporting form (Figures 2 and 3) is another very effective quality control system for in-patients. This was recently introduced into our laboratory and the preliminary results were very encouraging. This system uses the initial results of the patient as a control, and makes the analyst immediately aware of any changes. A sudden change in results from positive to negative, or vice versa, can thus be immediately investigated.

Maintaining a quality control programme by using a drug free sera and drug free urine has its own drawbacks as multiple drug usage is very high (2). Therefore, a cross-checking method by different techniques is of prime importance. When interpreting both thin layer and gas chromatography techniques (or any other techniques), their limitations should be kept in mind.

REFERENCES

1. Brandt, M. Karl, *Automated Thin Layer Chromatography,* American Laboratory, 87-94, September 1973.
2. Kapur, B. M., *Emergency Toxicology,* Abstract, *Clinical Biochemistry* 6, 333 (1973).
3. Larsen, J. W., Sorenson, H. C. and Townsend, C. W., A Proficiency Monitoring System for Drug Screening, *Clinical Toxicology Bulletin* 4, 39 (1974).
4. Mather, A., *Self-Evaluation Assistance Programme in Clinical Toxicology.* October 1971 – February 1973, Center for Disease Control, Atlanta, Georgia.

SECTION IV

Control and Prevention

Program Committee

Head: PHILIP J. FARMER

ROBERT F. BORKENSTEIN
HANS KLETTE
H. LAURENCE ROSS
REGINALD G. SMART

Cross-National Comparisons of Drinking Driving Laws

J.D.J. Havard[1]

Important changes have occurred recently in the number, distribution and severity of injury-producing road accidents in technically developed countries, with the result that the attention of public health authorities is now being directed increasingly towards legislative countermeasures as a means of reducing the associated mortality and morbidity (22). The disproportionate incidence of casualties in the 15-24 age group (Table I), an increasing number of which are found to be intoxicated by alcohol, underlines the importance of road accidents in reducing life expectancy and creates serious problems in terms of long-term morbidity. Not only do young victims stand a much better chance of surviving very serious trauma without dying from the consequences, but advanced and sophisticated techniques of medical resuscitation may also compound the problem by saving the lives of victims who would otherwise have died and by consigning them to long-term permanent incapacity. This is often of a most severe nature, particularly where damage to the brain or central nervous system is involved. The increasing differential velocity of modern road accidents, itself a consequence of advances in vehicle design and road construction which permit higher speeds, has led to higher proportion or irremediable damage to essential tissues and organs, at heavy cost both to the victim and to the community in the form of long-term disability.

The increasing number of motor vehicles on the road has led to important changes in the distribution of casualties amongst the different categories of road user. The increase in mortality and morbidity amongst car users in technically developed countries in the last decade has far outstripped that for pedestrians so that far more people are now being killed and injured *in* cars than *by* cars (Table II). Car drivers have now emerged as a high risk group in the community and legislative measures designed to modify the adverse human and environmental factors which increase the risk of accidents occurring whilst driving should occupy a very high priority. The purpose of this paper is to review the legislative measures which have been adopted by a number of technically developed countries in attempts to modify one of the most important of these factors, the influence of alcohol on the behaviour and performance of drivers.

In this connection it is important for public health authorities to emphasise the need for countermeasures to be based on scientific, including epidemiological, research. The ad hoc approach so long adopted by road safety authorities and admirably summed up by Baker (1) as "anything that sounds reasonable will be effective" is

---

[1] Under Secretary, British Medical Association, Tavistock Square, London, WC1H 9JP, England.

TABLE I *Percentage of Deaths Among Men due to Motor Vehicles in 1967, by Country, for all Ages Combined and in Age-Group 15-24*

Country	Number of deaths due to motor vehicle accidents per 100 deaths from all causes	
	All ages	15-24 years
Germany, Federal Republic	3.6	50.2
Netherlands	3.8	47.3
Denmark	3.2	45.6
Belgium	2.9	44.2
France	3.6	43.8
Austria	3.7	43.3
England and Wales	1.8	41.9
Northern Ireland	2.2	41.0
Sweden	2.0	35.3
Switzerland	3.8	34.2
Scotland	1.8	33.2
Finland	3.3	32.5
Greece	2.3	28.8
Czechoslovakia	2.5	28.1
Ireland	1.7	28.0
Norway	1.8	27.2
Iceland	3.1	24.1
Portugal	2.5	21.6
Bulgaria	2.3	20.3
Poland	1.8	14.9
Hungary	1.3	14.4

Source: World Health Organization (1970) World Health Statistics Annual 1967. I

TABLE II *Percentage Increase in Road Users Killed in 1970 as Compared with 1961 in Eight European Countries*

Country	All Road Users	Pedestrians	Private Car Users	Percentage Increase in Private Cars
France	65	54	150	99
Netherlands	59	29	241	306
Belgium	44	29	135	137
Austria	36	33	136	152
Germany	32	25	116	161
Switzerland	19	21	90	139
Italy	15	19	114	318
United Kingdom	9	8	86	90

Source: European Conference of Ministers of Transport (1972), Annex 1 (p. 49) and Table 1 (p. 29).

probably responsible more than anything else for the failure to contain road accident mortality and morbidity in technically developed countries. It has led to huge sums of money being expended with very little to show in terms of casualty savings and is one of the main reasons why the record of road safety authorities compares so badly with those responsible for controlling other important causes of mortality and morbidity such as industrial accidents. The scientific basis for "drinking-driving" laws rests largely on the epidemiological evidence provided in case control studies (4) of the increasing risk of accident involvement at various blood alcohol concentrations (BACs), and on the availability of practicable and reliable qualitative and quantitative methods of analysing the concentration of ethanol in the body fluids and in expired air. Detailed consideration of these subjects is given in other sections of these proceedings. This paper is concerned primarily with the way in which they are applied in the legislation in different countries.

TYPES OF LEGISLATION

A review of legislation to deal with the drinking driver must not only take account of the existence and nature of the laws concerned with driving under the influence of alcohol, it must also consider the means available for the enforcement of the law and for the disposal of drivers who are convicted under it. These considerations are interdependent in determining the effectiveness of the legislation as a whole, but perhaps the most important consideration is the extent to which the existence and enforcement of the law deters drivers from driving under the influence of alcohol. The point is made in order to draw attention to the need for legislation to be associated with an effective programme of education of the driving population. Legislation can reinforce such a programme but it can never replace it.

The Legal Significance of BAC[2]

Nearly all countries have introduced a specific offence of driving under the influence of alcohol, distinct from other offences involving alcohol, and distinct from other offences involving impairment of driving. Exceptions to this rule include West Germany where until recently the offence was prosecuted as part of a general offence relating to driving whilst impaired from any cause. During the preparation of this paper important amendment to the law in relation to driving whilst impaired by alcohol is reported to have been approved by the Bundestag (21).

It is convenient to study those countries which have introduced a specific offence, under two headings: those which have incorporated BAC as a constituent element of the substantive law and those which accept BAC only insofar as it provides evidence of impairment under procedural law along with other evidence. The advantage of introducing BAC as a constituent of the substantive law lies in its superiority over other evidence of alcoholic impairment of driving ability. The alternative methods of proof, which are limited virtually to observation of the driver's behaviour by police officers and clinical examination by a doctor, are grossly inferior. Unless the BAC is written into the substantive law these other methods of proof remain acceptable as evidence and can either establish or exclude alcoholic impairment of driving ability irrespective of the BAC.

---

[2] BAC is expressed in different ways in the legislation of various countries. In continental Europe the notation is promille or permille (grammes per litre on a weight/volume basis). In North America percentage values are given, usually on a weight/weight basis. In the United Kingdom and in most of its former Colonies BAC is expressed in mg/100 ml. In order to save confusion and to facilitate comparisons, all values given in this paper have been expressed in mg/100 ml, a method which has the advantage of avoiding the use of decimal points and commas. Exact conversion is not possible unless it is known whether the relevant law prescribes a weight/weight or a weight/volume ratio but for the purposes of this chapter a simple approximate conversion can be carried out by shifting the decimal point, e.g. 0.08% equals 0,8 promille, which equals 80 mg/100 ml. In order to save endless repetition the latter notation (which is used in this paper) will be expressed simply as 'mg', with occasional references to the percentage conversion which is used in the host country.

Introduction of an offence based on BAC does not always lead to repeal of previous legislation relating to the drinking driver. In the United Kingdom it has been found that powers of arrest under previous legislation are rarely used by the police if the screening breath test is positive because a conviction is far more likely to be secured under the new Act. If the breath test is negative the chances of conviction under the previous legislation are so remote that the driver is detained only in exceptional circumstances such as when impairment by other drugs is suspected. However, most cases known to the police of impairment caused by abuse of alcohol in combination with other drugs are associated with a relatively high BAC and may be expected to give a positive screening test.

The problems encountered by the police in detecting alcoholic impairment by observation are dealt with later in this paper. Insofar as clinical examination is concerned the literature contains many studies of the unreliability and non-specific nature of clinical tests for alcoholic impairment of driving ability. It has also been pointed out many times that by the time the driver comes under examination by the police doctor a psychological and physiological alarm reaction to his predicament may have occurred enabling him or her to perform clinical tests satisfactorily in spite of being intoxicated. This reaction does not affect the BAC. Conversely, cases have occurred where the doctor has decided the driver was impaired by alcohol whereas there was no alcohol present in the blood, so that evidence based on BAC provides a valuable safeguard.

These studies are now only of academic interest in those countries which have introduced offences based on BAC. They do however, continue to occupy the time of research workers in countries which have not yet taken this step, as they form part of the process of persuading the legislature that the existing law should be changed and placed on a scientific footing. Recent studies have only confirmed what was found in previous studies and should be regarded as wasteful and unnecessary. An example is provided by the situation in Finland where the Road Traffic Act provides that the results of clinical examination and other relevant factors may be taken into account by the court in reaching judgment. Complicated and sophisticated tests have been carried out in Finland using advanced computer techniques to analyse the results of clinical examination (25). The examinations were carried out by specially trained doctors with long experience in examining intoxicated drivers, but even under these conditions serious defects in the system were found to exist, particularly at low concentrations of alcohol. The reluctance of the courts and of the legislature in some countries to accept the evidence based on BAC as a constituent part of the substantive law is fairly characteristic of legal attitudes to expert scientific evidence. It is basic to legal philosophy that it is the function of the expert to offer advice and for the court (including the jury) to reach a decision on the expert advice and such other evidence as it chooses to receive. The introduction of BAC into the substantive law makes inroads on this precept by fettering the discretion of the court, and it is therefore resented. It was probably for these reasons that as late as 1931, decades after evidence based on X-rays had become available to provide incontrovertible evidence of the presence of a fetus *in utero*, the issue of pregnancy in a condemned woman prisoner was still being decided in England by a jury of 12 matrons, especially impanelled for the purpose, under the medieval writ *de ventro inspiciendo.*

Blood Alcohol Concentration as Evidence of Impairment

The extent to which courts pay attention to evidence based on BAC in circumstances where it is not an element of the substantive offence varies considerably. In accusatorial systems based on common law precepts the situation offers full scope for the 'battle of the experts' so that it is often very difficult to prove 'beyond reasonable doubt' that the driver was impaired by alcohol. Reference has already been made to the non-specific nature, unreliability and insensitivity of such alternative methods of proof as evidence based on clinical examination and observation by the police. Also, it is relatively easy for an astute defence lawyer to discredit expert evidence based on these methods in the eyes of juries which are not trained to assess expert evidence, and whose sympathies may often rest with the driver. In the United Kingdom, shortly before the introduction of a statutory offence based on a fixed BAC, it was noted that one-third of the drivers committed for trial and shown to have a BAC in excess of 200 mg (0.2%) were being acquitted and nearly half of those with a BAC of 150-200 mg (0.15%-0.2%) (23).

In countries with inquisitorial systems based on civil law precepts, the arrangements for receiving expert evidence are generally much more satisfactory and considerably more attention is paid by judges to evidence based on BAC. Indeed, in many such countries conviction is almost automatic at certain concentrations of alcohol as a result of established court practices, even though no fixed concentration is stated in the substantive law. The courts nearly always convict at 150 mg (0.15%) in Belgium, at 130 mg (0.13%) in West Germany (until the recent change in the law) and at 100 mg (0.1%) in Denmark, although in Denmark it is often necessary for the prosecution to take the case to appeal in order to get a conviction. Below these concentrations the practice varies. In Belgium a conviction is highly unlikely below 150 mg (0.15%). In Denmark the offence of second degree intoxication is recognised, and convictions for that offence can be obtained at about 80 mg (0.08%), provided the case is supported by convincing evidence from other sources such as police observation and clinical tests. However, a recent survey in Denmark showed that only 45% of drivers with a BAC between 50 mg and 80 mg were found to be under the influence of alcohol by police doctors (26). Convictions could also be obtained in West Germany at concentrations below 130 mg (0.13%) provided there was sufficient supporting evidence and the concentration was in excess of 80 mg (0.08%).

The Uniform State Model Vehicle law in the United States recommended that impairment should be presumed at 150 mg (0.15%) and excluded below 50 mg (0.05%). In between these concentrations it was recommended that the presumption that the driver was impaired by alcohol could be rebutted by other evidence. More recently the National Highway Traffic Safety Administration (14) recommended the introduction into the legislation of an offence based on a BAC of 100 mg (0.1%). In the meantime a number of states had already adopted such a law in favour of previous legislation based on the presumptions in the model law. The position at the time Farmer (18) reviewed the law in 1973 was that two states had adopted a BAC of 80 mg (0.08%), 32 states 100 mg (0.1%), one state 120 mg (0.12%) and the remaining 9 states were still operating the model code at 150 mg (0.15%). The fact that BAC is not an inherent part of the substantive offence allows the courts considerable latitude in dealing with these cases, and the prospects of conviction inevitably influence the prosecution in deciding whether to bring the case to court. Attitudes may vary not only between different countries but within the same country. Philips (26) reports one federal judge in Schleswig, West Germany as stating that he had to remit about 75% of cases to the lower courts for retrial because of failure to convict. The Belgian courts so rarely convict drivers at a BAC lower than 150 mg (0.15%) that it is the practice not to prosecute below that level. In Denmark it is alleged that the police will only present cases for prosecution where there is substantial evidence of intoxication and that the prosecuting authorities, which are independent of the police, scrutinise the cases presented by the police with great care before deciding to prosecute (26).

Although the introduction of a substantive offence based on a fixed BAC resolves many of these difficulties, the resistance of the courts may still be considerable, particularly in common law countries adopting the accusatorial system. In the U.K., the courts were prepared to go to extraordinary lengths to avoid convicting drivers, even those with two or three times the statutory limit. For a time almost any technical defect in the procedure was held by the lower courts to provide an excuse for not returning a conviction. It was necessary to go to the Court of Criminal Appeal to prove that a driver could not insist on blood being taken from his penis and to the highest appeal court in the land (House of Lords) to decide that a driver could not elect for his big toe. In one case a driver was acquitted on the fiction that there are only four gas chromatographs (necessary for analysing micro-samples) in the U.K.

In concluding this section it is important to emphasise that the opinions expressed about the value of clinical examination apply only to its use as a method of determining alcoholic impairment of driving ability. It must not be assumed that it has no place at all in the medico-legal procedure for dealing with drivers suspected of the offence. Many clinical conditions mimic alcoholic intoxication, particularly head injuries which are a common sequel of road accidents. Abnormal behaviour may be caused by conditions other than alcoholic intoxication such as illness, injury, or the effects of drugs other than alcohol. These must always be borne in mind when a driver presents with abnormal behaviour so that the necessary medical treatment can be given. Indeed, it would appear from the very high BACs recorded in some cases that the driver may sometimes be in need of treatment for alcoholic toxaemia. It follows that in those countries which incorporate BAC as part of the substantive offence, it is still necessary to provide arrangements for clinical examination in appropriate cases and for the examination to be carried out by doctors experienced in medico-legal procedures.

Blood Alcohol Concentration as a Constituent of the Offence

In 1967 the European Conference of Ministers of Transport (16) recommended that member countries introduce a statutory offence based on a BAC not exceeding 80 mg (0.08%). This recommendation was made on the advice of OECD Expert Group on the Effects of Alcohol and Other Drugs on Driver Behaviour as set out in the report of the Group's consultants (20). A number of European countries have followed this recommendation. Some European countries had introduced legislation based on a fixed BAC at a very much earlier date. Norway introduced an offence based on a level of 50 mg (0.05%) in 1927 long before any evidence based on epidemiological studies was available as to the extent of the risk of accident involvement at that concentration, although evidence of impairment from laboratory studies on skills resembling driving was available at that time. Sweden followed suit soon afterwards. Austria introduced an offence based on a level of 80 mg (0.08%) in 1961 and has since been followed by Switzerland, U.K., Netherlands, France and West Germany. The Republic of Ireland has introduced an offence based on a level of 125 mg (0.125%).

In some countries the offence or offences are linked to two different concentrations carrying different penalties on conviction. In Sweden the first degree offence set at 150 mg (0.15%) is punishable by imprisonment up to one year with the option in extenuating circumstances of not less than 25 'day fines' (one 'day fine' is the equivalent of 1/1000th of the annual income of the driver). A second degree offence set at 50 mg (0.05%) (but not exceeding 150 mg) is punishable by not less than 10 'day fines' or imprisonment up to 6 months. Withdrawal of the licence for varying periods is automatic in both cases. In France the first degree offence set at 120 mg (0.12%) carries imprisonment for a period of 1-12 months and a fine of 500-5000 francs. The second degree offence fixed at 80 mg (0.08%) carries imprisonment for 10 days to a month and a fine of 400-1000 francs. Iceland also has two degrees of offence set at 120 mg (0.12%) and 50 mg (0.05%) respectively. The Australian states have introduced offences based on a BAC of 80 mg (0.08%), with the exception of Victoria where the level is fixed at 50 mg (0.05%). In New Zealand the statutory offence is based on a BAC of 100 mg (0.1%). There is a wide variety of offence in the United States but the National Highway Traffic Safety Administration (14) has recommended states to introduce offences based on a statutory BAC of 100 mg (0.1%). However, this recommendation had already been anticipated in several states. Canada has introduced an offence based on a BAC of 80 mg (0.08%). The situation varies in East European countries, but most of them have introduced laws making it an offence to drive after taking any alcohol whatsoever. In most cases this is interpreted by the courts as requiring conviction if the BAC is in excess of 30 mg (0.03%) , e.g. Czechoslovakia and East Germany, which is regarded as a generous allowance for errors in the analytical method.

PROBLEMS OF ENFORCEMENT

The Provision of Samples for the Courts

Whilst the introduction of a fixed BAC into the substantive law will solve most of the problems of proving alcoholic impairment, the effectiveness of the law will depend on the legal powers which are available for its enforcement. It would be pointless to introduce a substantive offence based on a fixed BAC in Italy so long as the constitutional position in that country prevents the police from obtaining a sample of blood from a living driver in any circumstances. In many countries with fixed constitutions, the powers which can be exercised by the police in detecting drivers who are impaired by alcohol and in obtaining the necessary proof, are severely limited. In the United States the introduction of effective legislation was handicapped in many states by the constitutional position over self incrimination (fifth and fourteenth amendments), the right of privacy and other legal problems (15). A series of cases in the courts was necessary to clear the way and devices such as the "implied consent law", whereby a driving licence is issued only on condition that the driver provides a sample of blood upon a reasonable request by a police officer, ran into constitutional difficulties (30). The National Highway Traffic Safety Administration (14) has recommended that states introduce legislation requiring drivers (in cases where a breath test indicates that the driver is impaired by alcohol) to provide the necessary sample on pain of the licence being revoked for 6 months, specific protection being provided for those drivers who object "on valid religious or medical grounds".

In some European countries such as West Germany, Sweden and Denmark there is no need for such a provision as the police have powers, on reasonable suspicion of alcoholic impairment to obtain samples of blood from drivers against their will, using physical force if necessary. In other European countries, where the police do not have such powers, various factors come into play to ensure that drivers gain no advantage by refusing to provide a sample. In the U.K. a driver who refuses to provide a sample of blood or urine is automatically found guilty of the offence of exceeding the 80 mg (0.08%) limit, and is punished accordingly. However, he cannot legally be required to provide a specimen unless at least two positive readings have been obtained by a qualitative (screening) breath method. In the Netherlands there is no statutory obligation to provide a sample and as many as 40% of drivers detained by the police are said to refuse, but the courts are allowed to take the fact of refusal into consideration and nearly always convict the uncooperative driver of the offence (26).

Screening Procedures

Even though powers may exist to obtain samples from drivers suspected of the offence there still remains the problem of detecting those drivers who should properly be regarded as providing grounds for suspicion. The most valuable aid in this connection is the qualitative (screening) breath test. Although the existing instruments, as compared with the quantitative breath methods, are unreliable and relatively crude, they are cheap, portable and far more efficient than the police officer's own powers of observation. As a result they are used increasingly by police officers and the procedure by which drivers can be required to take screening breath tests is set out in most of the recent legislation.

The Swedish Government Committee (31), set up to review legislation on the drinking driver, conducted a number of studies at simulated roadblocks to assess the reliability of police observation in detecting alcoholic impairment of driving ability. The Committee concluded that the chances of a police officer detecting the smell of alcoholic liquor and other signs of intoxication were remarkably low. The majority of drivers with a BAC between 50 mg and 150 mg (0.05 - 0.15%), and nearly half of those with concentrations in excess of 150 mg, aroused no suspicion on the part of the police.

It follows that screening procedures are unlikely to be effective if the legal powers of the police to obtain a breath test are limited to drivers who they have reason to believe are impaired by alcohol, and it is therefore necessary to extend those powers beyond such cases. The political controversy which has been engendered by such proposals is commonly, but wrongly, labelled as "random testing". A procedure based on random tests would require the tests to be carried out in accordance with a predetermined randomly selected procedure entirely free of bias, so that a grossly intoxicated driver who was not included in the sampling method would have to be ignored and allowed to go free. What is meant by 'random' testing in the context of the present controversy is the free exercise of selective testing by the police, so that the police may require a test to be taken in circumstances where they believe there is a good chance of the driver's being intoxicated even though they have no positive evidence to suggest the driver is impaired by alcohol, *i.e.* the opposite of random in the scientific sense of the term. Selective testing of this kind carried out at selected times of the day, days of the week, and on particular roads, in circumstances where drivers impaired by alcohol are most likely to be found, would be far more effective than random testing.

An interesting example of selective testing which has been highly effective can be found in the recent United Kingdom legislation which empowers a police officer to require a driver, under pain of a fine for refusal, to take a screening breath test in cases where he has been involved in an accident or where he has committed a traffic offence whilst the vehicle is moving, irrespective of the presence or absence of signs of intoxication. Similar provisions exist in some other European laws, including Norway where the police also have powers to set up roadblocks for the purpose of conducting tests. According to Bø (3) roadblocks are widely used in Norway, especially in suburban areas where between 500 and 700 drivers may be tested at a time. An opportunity is taken to check any mechanical faults in the vehicle at the same time. In France a breath test may be required from any driver involved in an accident and from drivers involved in offences against the traffic regulations, but not on other grounds. Farmer (19) has attributed the relative failure of the new Canadian law (based on a BAC of 80 mg or 0.08%) to the lack of provision of adequate screening procedures. Whereas it was estimated that an increase in arrests of about 500% would have occurred following the introduction of the 80 mg level, an increase of only 59% was recorded. But most recent legislation requires the police to have reasonable grounds to believe the driver has been drinking before a screening breath test or a sample of blood can be obtained. The Motor Car (Driving Offences) Act 1971 in the Australian State of Victoria, requires the police officer to satisfy himself that the driver has consumed alcohol within the previous two hours and that the driving ability is thereby impaired. The Transport Act of New Zealand requires the police "to have good cause to suspect" that a driver is in breach of the law before requiring the driver to take a breath test, but the Government Road Safety Committee (24) declined by a majority to recommend any extension of these powers after they have been told by the police that the existing powers did not limit their enforcement powers to any serious extent. The Committee pointed out that the police had powers 'on reasonable grounds' to impound ignition keys, immobilise vehicles and prohibit drivers from driving, and expressed the view that it was more important to extend this preventive activity than to permit such drivers to drive and then to carry out a breath test. The Belgian law specifically permits the police to do just this if the screening breath test indicates the BAC is in excess of 80 mg (0.08%). The driver is allowed to request a repeat of the breath test at intervals not exceeding two hours and his vehicle is returned to him as soon as the screening breath test indicates a level below 80 mg (0.08%) (10, 26). However, this assumes that the driver is safe to drive as soon as the BAC is below 80 mg (0.08%) and it also relies on the accuracy of the breath test. Neither of these assumptions can be accepted. The Swedish Government Committee (31) took a different view from the New Zealand Road Safety Committee and recommended that the police be authorised to take 'routine' breath tests in association with pre-arranged roadblocks.

The "implied consent" law adopted in most of the United States does not become effective until an arrest has occurred and the constitutional position requires the police officer to have 'probable cause' before he can effect an arrest. The recent "Stop and Frisk" case decided by the Supreme Court suggests that an officer might be within the law if he requires a breath test in circumstances where he suspects a traffic violation to have occurred, and that other gorunds not amounting to "probable cause", such as involvement in an accident might also be permitted (15).

Hospital Cases

In many countries the driver escapes the enforcement net if he is admitted to hospital and it is interesting to note how this was dealt with under the recent UK legislation. Early versions of the Act made no provision for samples of breath or of blood to be taken from drivers admitted to hospital, and as involvement in an accident is one of the three statutory criteria on which a breath test can be obtained it was clear that the absence of any legal provision in hospital cases provided an important loophole. It was the medical profession itself which suggested that the necessary provision should be included in the Act, subject only to two conditions (5). First, the doctor in charge of the case should give his permission and secondly samples for analysis on which the prosecution would rely must be taken by independent doctors, preferably a police surgeon, who has no responsibility for the treatment of the patient. In practice, the provision has given rise to no difficulties and the hospitals in the U.K. are no longer a haven of refuge for the intoxicated driver.

It would appear that the medical profession in New Zealand has been less co-operative as the Government Road Safety Committee has complained that some hospital doctors were refusing to allow samples to be taken from patients for purposes of law enforcement (24). The European Conference of Ministers of Transport (ECMT) attribute the underestimate of alcohol related accidents in its survey almost entirely to drivers escaping detection by necessary (or deliberately unnecessary) recourse to medical treatment (17).

DISPOSAL

Penalties on Conviction

The three main penalties attached to the offence of driving whilst impaired by alcohol are imprisonment, fines and disqualification from driving by suspension of the driving licence. In some cases penalties are graded according to the severity of the offence. Penalties may also be graded according to the history of previous offences. In the United States the National Highway Traffic Safety Administration has recommended that, on a second conviction within 10 years, registration of the vehicles(s) owned by the driver should be suspended as well as the driving licence (14). It has already been noted that in Sweden the penalty of a fine is made more effective by relating the fine to the annual income of the driver (day fines). In most countries suspension of a driving licence for varying periods is automatic on conviction for the offence of driving under the influence of alcohol. In some countries the offence forms part of a ‘points’ system in which repeated offences are taken into consideration. This system was commended by the Council of Europe (9), although the Council’s Committee of Ministers was only prepared to consider suspension as appropriate for the alcohol offence if the driver had been proved to have been a ‘real danger’ (Konkrete gefährdung) in traffic, and was unwilling to recommend automatic suspension in other cases, even at concentrations in excess of 120 mg (0.12%), on the curious ground that it might operate where the driver drives his car from the garage premises into his garage.

Recidivism

One of the problems associated with legislation against the drinking driver is that it so often fails to take into account the idiosyncrasies of the convicted driver. The amount of alcohol required to reach a BAC of 80 mg (0.08%) under conditions of ordinary social drinking is quite considerable and would be regarded as excessive in ordinary social circles. Reference to the literature will confirm that at around 80 mg (0.08%), ordinary subjects participating in experiments on the effects of alcohol become subjectively affected to an uncomfortable degree and are reluctant to continue drinking. Workers in many countries have noted that drivers convicted above this level frequently have alcohol problems. Bjerver (2) noted that of 804 persons convicted for driving under the influence of alcohol in Sweden in 1964, 64% were already known by the authorities for alcohol offences not connected with driving. Without entering into the controversy over the definition of alcoholism it may be stated that many convicted drivers will be likely to repeat the offence if their licences are restored without their alcohol problems being resolved by treatment, and very few countries require treatment as a condition of restoring the licence.

Forty per cent of all prison sentences in Sweden each year are for driving under the influence of alcohol, and drivers convicted of this offence constitute 10% of the prison population. The Government Committee appointed in Sweden (31) to review the legislation on the drinking-driving offence drew attention to the need for such sentences to be combined with treatment of the alcohol problems of the inmates, and emphasised that the prospects of satisfactory treatment are good insofar as the driver convicted of the offence is often in an early state of the disease. The National Highway Safety Administration (14) of the United States has recommended that courts should be given powers to commit medically diagnosed alcoholic drivers to a hospital or clinic rather than to prison, on conviction of the offence. A number of workers in other countries have noted that conviction of a drinking driving offence is frequently an early symptom of alcoholism. This has been confirmed in a recent survey carried out in Ireland where the histories of 100 male alcoholic drivers of cars were compared with matched controls (7). Whereas the average alcoholic received his first formal treatment for alcoholism at about the age of 38, he had been involved in his first road accident involving alcohol at least 6 years previously. Over a third of the alcoholic sample had been admitted to hospital for treatment of physical conditions related to, or associated with, alcoholism and were recognisably suffering from alcoholism. Nevertheless, many of them received no formal treatment for their alcoholism for four years or more after discharge from hospital, during which period they were involved in road accidents associated with alcohol. The authors conclude that the diagnosis of alcoholism is still being missed because those who come into contact with the patient, including doctors, nurses, social workers and law officers, are not alert to the problem and may often assume that the average alcoholic conforms to the stereotype 'skid row' down-and-out. The fact that the majority of alcoholics are well-dressed and healthy-looking for most of their drinking careers is not generally appreciated. Failure to treat the underlying condition in drivers with alcohol problems is one of the main causes of the high recidivist rate attached to the offence. Raymond (27) has reported that at least 25% of drivers convicted of the offence in Melbourne repeat the offence, some of them as many as four or five times. More still may repeat the offence without being apprehended or may escape altogether through being killed or injured in an accident. A Select Committee of the State Parliament in Victoria (Australia) recommended that all drivers convicted of the offence with a BAC of more than 150 mg (0.15%) should be assessed medically in order to see whether treatment of the alcohol condition was necessary (28).

Buikhuisen (6) has carried out a detailed survey of the problem. In a review of the literature he mentions 11 reference to studies in different countries showing the high frequency of recidivism amongst drivers convicted of the offence. In his own study of the criminal records in the Netherlands he found that there was no inverse relationship between the severity of the sentence and prospect of recidivism. What he did find was that there was a positive relationship. The longer the prison sentence the more likely the driver is to repeat the offence.

EVALUATION

Criteria for Evaluation

Scientific evaluation of countermeasures against road traffic accidents is a very difficult exercise, and very few examples exist which will satisfy the necessary tests of credibility. The main reason for this is the lack of adequate baseline data against which the performance of a new countermeasure can be assessed.

Law enforcement agencies, transport authorities and public health authorities have different criteria for assessing the results of countermeasures, but the ultimate test as far as the community is concerned is always the effect on the rate of mortality and morbidity from road traffic accidents. In the case of alcohol related offences this test is particularly important because surveys have repeatedly shown that where alcohol is a factor an accident is far more likely to be serious in terms of the severity of injuries received by the casualties.

The first requirement of a scientific method of evaluation is a reliable system of reporting of road accident mortality and morbidity. The most recent developments in this connection have been a series of surveys which have shown gross discrepancies between the police returns of road accident casualties, on which transport authorities

TABLE III *Drivers Involved in Road Accidents whilst under the Influence of Alcohol in 13 European Countries – 1968-1972*

	Total Number of Registered Cars in Tens of Thousands					
Country	1970	1968	1969	1970	1971	1972
W. Germany	110.16	35765	36276	42188	42894	44926
U.K.	103.18	–	4176	5738	7614	9376
Italy[a]	73.11	–	–	–	186	317
Sweden	19.67	–	1004	1054	–	1180
Netherlands	17.25	–	2231	2624	2689	2944
Spain	13.35	235	241	264	262	291
Switzerland	9.79	3016	3432	3747	4385	–
Austria	9.65	2145	2252	2503	2724	–
Denmark	8.88	1009	1074	1410	1345	1719
Finland	5.51	766	539	592	685	757
Czechoslovakia	5.21	1824	–	–	–	–
Yugoslavia	3.56	1648	1754	–	3539	3815
Poland	3.32	–	–	–	377	816

Source: Economic Commission for Europe, *Statistics of Road Traffic Accidents in Europe.* United Nations, Geneva. Publications for years concerned.

[a] Figures for Italy include *all* road users.

depend for purposes of evaluation, and the numbers of persons actually injured in road accidents and treated in hospitals and clinics. Both the World Health Organisation (32) and the Council of Europe (11, 12) have drawn attention to the highly unsatisfactory nature of the official returns of morbidity from road traffic accidents, and the Economic Commission for Europe (ECE), which publishes an annual volume of statistics of road traffic accidents in Europe, has recently called a series of meetings of the Group of Experts with a view to improving the position. If the total returns of road accident mortality and morbidity are so unreliable, it cannot be expected that the detailed returns will be any less unreliable, and the point is made by the information given in the ECE annual statistical volumes since 1968 on road accidents in which drivers involved are found to be under the influence of alcohol (Table III).

The discrepancies between the countries are far too great to be explained by the variable factors prevailing in different countries. It cannot be accepted that a major wine producing country like Italy, with one of the largest pools of motor vehicles in Europe, had only 182 road accidents in 1970 in which the road users involved were under the influence of alcohol. Even when special survey techniques are applied it is highly doubtful whether any credence can be attached to the results. Results of the survey conducted by ECMT (17) into accidents involving bodily injuries in which alcohol was a factor, are shown in Table IV.

TABLE IV *Accidents Involving Bodily Injuries in which the Driver was Under the Influence of Alcohol*

Country	Accidents Involving Bodily Injuries
Germany	15.0%
Austria	6.9%
Belgium	5.0%
Spain	35.0% (estimate)
France	—
Italy	0.6%
Luxembourg	6.6%
Switzerland	6.6%
Yugoslavia	19.3%
Average rate:	8.4%

Source: European Conference of Ministers of Transport (1972), page 23.

The comment attached to the Table was that the proportions "seem far short of the actual facts" and the conclusion was reached "that the seriousness of the problem of drunken driving might be minimised if judged in the light of the calculated average figure (9.9%)". The shortfall in the figures was attributed almost entirely to drivers escaping detection by being admitted to hospital following the accident, although no facts are given in support of this supposition.

Methods of Evaluation

Time-series studies on casualty savings. In spite of the qualifications which must be attached to the official returns of road accident casualties it is sometimes possible to attempt a scientifically based evaluation of countermeasures by reference to the effects on overall road accident mortality and morbidity. Ross (29) subjected the recent U.K. legislation to a searching examination in this respect, employing a time-series analysis. The methods he adopted, which repay careful study, showed conclusively that the Act "did produce a sharp and important decline in traffic casualties although this effect may have been partly the result of the accompanying publicity campaign". If the record of previous publicity campaigns is anything to go by the decline must have been almost entirely due to the Act.

Level of blood alcohol concentration in the driving population. Another method of evaluation is to compare the distribution of BAC amongst drivers before and after the countermeasure has been introduced in order to determine whether the measure has had any effect on drinking habits in relation to driving. This is very rarely possible in practice as legal problems usually prevent fully representative sampling of drivers. The development of roadside screening surveys is under way as part of the international collaborative programme administered jointly by the organization for economic cooperation and development and by the Committee on Challenges in a Modern Society (CCMS) of NATO.

A selective variation of this method of evaluation was carried out in the U.K. where the BACs of all drivers killed in road accidents were recorded for a period of nine months before the Act became effective in October 1967, and it is possible to compare the changes which occurred subsequently. As might have been expected, the proportion of drivers killed at higher concentrations, representing predominantly alcoholics or compulsive drinkers, has now returned to the pre-1967 value (8) but the effects of the Act can still be seen in the proportions at lower concentrations representing moderate or social drinkers (Table V).

TABLE V *Motor Vehicle Drivers Aged 16 Years or more Killed in England & Wales (Died within 12 hours of an Accident)*

Period	Percentage with blood-alcohol exceeding (mg/100 ml) 9	50	80	100	150	200
Before the legislation Dec. 1966 to Sept. 1967	37	29	25	22	13	6
After the legislation Dec. 1967 to Sept. 1968	26	17	15	14	9	4
Dec. 1968 to Sept. 1969	29	22	19	17	11	5
Dec. 1969 to Sept. 1970	30	23	20	17	12	6
Dec. 1970 to Sept. 1971	37	31	26	23	15	6

Source: Transport and Road Research Laboratory (1974) *Blood Alcohol Levels in Road Fatalities,* LF 391.

The 'Shock' Effect

As with most legislation aimed at influencing the behaviour of road users, a 'shock' effect is very often noticeable immediately after the legislation has been introduced and this has been a fairly constant feature in the case of legislation on alcohol and road traffic. It was noticeable in Austria (22) following the introduction of the offence based on a BAC of 80 mg (0.08%) in 1961 and it was very marked in the U.K. during the period immediately following the Road Safety Act 1967, when the casualty savings were far greater than could have been expected even if the Act has been fully effective in preventing drivers from taking the road at BACs in excess of 80 mg (0.08%). The probable explanation is that drivers knew they could be required to take a breath test if they had been involved in an accident or a moving traffic offence and were therefore driving more carefully whether or not they had been drinking. As the shock effect wears off the drinking driving population begins to assess the risk of being detected whilst driving after drinking so that any falling off of the effectiveness of legislation becomes closely related to the level of enforcement. The casualty savings following the Act can, however, be shown to have continued over a long period by the chart in Figure 1.

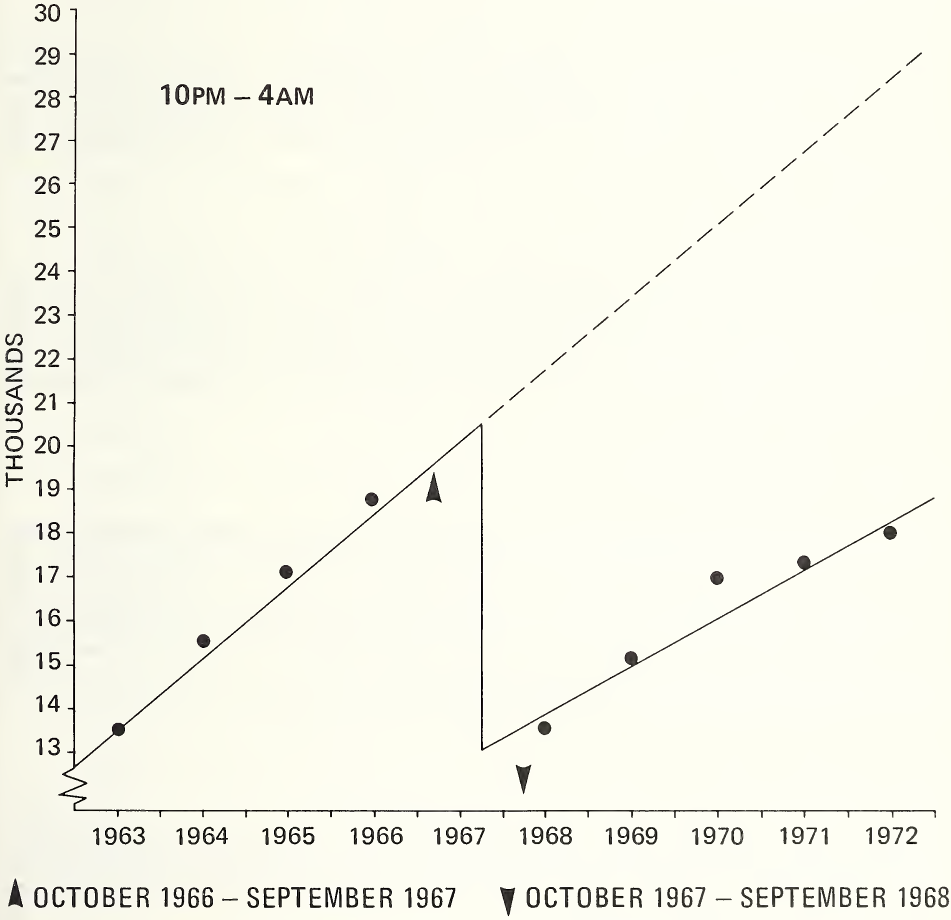


Figure 1 *Trends in numbers of car involvements in fatal and serious accidents – (1963-1972). Source: Department of the Environment (1942),* Road Accidents in Great Britain, *1972, HMSO.*

CONCLUSION

The limited review in this paper of comparative legislation suggests that the following principles are important in the introduction of effective legislation.

Detection

Drivers should be required to take a screening breath test whether or not they exhibit signs or symptoms of alcoholic intoxication, and law enforcement officers should be given powers to stop traffic for the purpose of taking such tests. These powers should be exercised in a highly selective manner at times and places where persons are most likely to be found driving under the influence of alcohol. Subject to suitable safeguards, drivers receiving treatment in hospitals and clinics following road accidents should also be required to take a screening breath test.

Confirmation

Drivers suspected of driving under the influence of alcohol as a result of the screening breath test should be required to provide a sample of blood for quantitative estimation of the concentration of alcohol in the blood. Subject to suitable safeguards this requirement should also apply to drivers attending hospitals or clinics following road accidents.

Conviction

Driving with a blood alcohol concentration in excess of a statutory limit should be regarded as a separate offence, distinct from other offences involving driving whilst impaired. Conviction of the offence should be mandatory if the blood alcohol concentration is proved to have been in excess of the statutory limit, which should not exceed 80 mg (0.08%).

Disposal

Suspension of the driving licence for a period of at least one year should be mandatory in all cases where persons have been convicted of the offence and courts should have powers to place conditions on the return of the licence at the end of this period, e.g. completion of treatment for an alcohol condition or satisfactory performance of a driving test. Courts should have powers to remand drivers for medical examination before sentence and should have discretion to order a period of medical treatment in lieu of imprisonment or fines in appropriate cases.

Evaluation

Authorities responsible for the prevention and control of road accidents should ensure that adequate baseline data are collected before the introduction of any changes in legislation so that its effects can be evaluated by scientific methods and the need for any further changes fully assessed.

It appears from the view in this paper that whereas nearly all technically developed countries have adopted one or more of the above principles in legislation, none has adopted all of them. If the mortality and morbidity caused by drivers under the influence of alcohol is to be reduced effectively legislation must ensure not only that the drinking driver is detected and convicted, but that the case is disposed of in such a way that the risk of the offence being repeated is also reduced.

REFERENCES

1. Baker, S. P., Injury Control – Accident Prevention and Other Approaches to Reduction of Injury. In *Preventive Medicine and Public Health*, 10th Ed. Appleton Century Crofts. New York, 1973. (Awaiting publication)
2. Bjerver, K. B. Punishment or Treatment for Intoxicated Drivers. *Blutalkohol* 9, 59 (1972).
3. Bø, O., *Norwegian Countermeasures to Driving under the Influence of Alcohol and Other Drugs.* Paper read at the International Symposium on Countermeasures to Driver Behaviour under the Influence of Alcohol and other Drugs. British Medical Association, London, England, 22-23 Sept., 1971.
4. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Zill, W. B., Zylam, R., *The Role of the Drinking Driver in Traffic Accidents.* Department of Police Administration, Indiana University, Bloomington, Indiana, 1964.
5. British Medical Association. *The Drinking Driver*, London, England, 1965, p. 36.
6. Buikhuisen, W., *Criminological and Psychological Aspects of Drunken Drivers.* Criminological Institute, State University of Croningen, Netherlands, 1969.
7. Clare, S. W. and Cooney, J. G., Alcoholism and Road Accidents. *Journal of the Irish Medical Association* 66, 281 (1973).
8. Codling, P. J. and Samson, P. *Blood Alcohol in Road Fatalities before and after the Road Safety Act 1967.* TRRL Supplementary Report 45 UC, Crowthorne, England, 1974.
9. Council of Europe, *Explanatory Memorandum on the Resolution on the Deprivation of the Right to Drive a Motor Vehicle* (adopted by the Committee of Ministers) B(71) 102 Annex II Strasbourg, France, 1971, pp. 3-4.
10. Council of Europe, *Report on Action Taken by Member States* (Resolution (68)31 on Road Accident Prevention CESP(73) 20, Strasbourg, France, 1973.
11. Council of Europe, *Structure and Organisation of Road Accident Prevention*, Strasbourg, France, 1970, p. 93.
12. Council of Europe, *Accidents in Childhood as a Public Health Problem*, Strasbourg, France 1972, p. 29.
13. Department of the Environment, *Road Accidents in Great Britain in 1972.* HMSO, London, England, 1974.
14. Department of Transportation, *Safety Administration Highway Safety Program Standards*, para. 242.6., Federal Register 37 (No. 150), Part II, Washington D.C., U.S.A. 1972, pp. 15602-15621.
15. Department of Transportation, *1968 Alcohol and Highway Safety Report.* Committee on Public Works Paper 90-34 90th Congress, 2nd Session, U.S. Government Printing Office, Washington, 1968, Chapter 7.
16. European Conference of Ministers of Transport, *Resolution No. 21 passed by 17th meeting of the Council of Ministers*, 14th June 1967. Organisation for Economic Co-operation and Development, Paris, France, 1967.
17. European Conference of Ministers of Transport, *Report on Recent Trends in Road Accidents*, C.M. (72)10, Paris, France, 1972, pp. 23-24.
18. Farmer, P. J., Review and Evaluation of Legislation and Evaluation of Legislative and Enforcement Programs Related to the Use of Alcohol and Other Drugs. *Proceedings of the Conference on Medical, Human and Related Factors Causing Traffic Accidents including Alcohol and Other Drugs.* Traffic Injury Research Foundation of Canada, Ottawa, Ontario, Canada, 1973, pp. 55-64.
19. Farmer, P. J., *The Role of Legislation and Community Education in the Prevention of Alcohol Related Traffic Accidents.* Symposium on Alcohol, Drugs and Traffic Safety, 8th Annual Conference of Canadian Foundation on Alcohol and Drug Dependencies, 1973.
20. Goldberg, L., and Havard, J.D.J., *Research on the Effects of Alcohol and Drugs on Driver Behaviour.* Organisation for Economic Co-operation and Development, Paris, France, 1968.

21. Handel, K., Anwendung und Auswirkungen des 0,8 – promille Gesetzes. *Blutalkohol* **10**, 353 (1973).

22. Havard, J.D.J., Road Traffic Accidents. *WHO Chronicle*, 27, 83 (1973).

23. Ministry of Transport, *Road Safety Legislation 1965-6*, HMSO London, 1965, para.20.

24. *New Zealand Road Safety Committee 1972*. Paper L. 17 Government Printer, Wellington, New Zealand, 1972.

25. Penttila, A., Tenhu, M. and Kataja, M., *Clinical Examination in Cases of Suspected Drunken Driving*. Reports from *Talja* Vol. 11. Central Organisation for Traffic Safety in Finland. Helsinki, Finland, 1971.

26. Philips, P., *Alcohol and Road Safety*. Report of Investigations and Observations into these matters in Europe during 1969 to the Honourable the Minister of Health of the State of Victoria, Melbourne, Australia, 1970.

27. Raymond, A., Characteristics of drivers breathalysed in Melbourne in 1967. *Proceedings of the Fifth Conference of the Australian Road Research Board* 5, 209-228 (1970).

28. Raymond, A. *Alcohol in Relation to Road Safety*. Australian Road Research Board, Doc. NR/3, Melbourne, Australia, 1972, p. 41.

29. Ross, H. L., Law, Science and Accidents. The British Road Safety Act of 1967. *The Journal of Legal Studies* (University of Chicago Law School) 2, 1-78 (1973).

30. Schaeffer, S. L., Constitutionality of "Implied Consent" Statutes. In *The Enforcement of Traffic Laws – Some Current Legal Problems*. Highway Safety Research Institute, University of Michigan, Ann Arbor, 1967. pp 35-43.

31. Swedish Government Committee to Review Legislation on Driving under the Influence of Alcohol (SOU. 1970:61) Stockholm, Sweden, 1970, Summary, paras. 19-20.

32. World Health Organization. Availability of Accident Statistics. *World Health Statistics Report* 25, 756-758 (1972).

Problems of Enforcement, Adjudication and Sanctioning

Robert F. Borkenstein[1]

A dozen years ago, the North American continent had half the improved highways and three-quarters of all the automobiles, vans, and trucks of the world. This system served only about seven per cent of the world's population (6).

In spite of the continuing increase of such vehicles on this continent, we are rapidly losing our plurality. The automobile age is exploding everywhere in the world. In Asia, the rickshaw and pedicycle have given way to the truck, bus, motor scooter, and taxi. The bullock cart is fading from Delhi, and the camel from Karachi. In nations such as England and Germany, the man who two decades ago would have denied the need for an automobile is now the head of a two-car family. The traffic jam has become a world-wide problem (7).

All this has happened in about half a century. Sixty years ago North America was producing more horse-drawn vehicles than motor cars. Obviously, as human control of these vehicles replaced animal sense, regulatory systems had to be developed. These eventually became traffic laws, suited to the needs of the day for their particular jurisdictions, but hardly necessary or directly transferrable to those nations still in the primitive stages of motor transportation.

In any nation, mobility through transport goes through a series of stages. First there is low mobility, due to primitive conditions; then comes ox-cart mobility, adequate to carry on inter-tribal or inter-village trade; third is mechanized transport, necessary to support an industrialized society; fourth is the new mobility – the automobile and an efficient mass transport system; fifth is the conquest of distance through air and space travel; and, finally, a return to low mobility through affluence – too many cars, too little fuel, high cost of transportation, strangled streets and highways, and excessive pollution of the atmosphere.

Since the American continent was first to experience the extreme expansion of the automobile, it was also the first to face the need to develop countermeasures against the principal early dysfunction of the system – traffic crashes resulting in death, injury, and property damage.

One of the earliest factors recognized as needing regulation was the impact of alcohol misuse on the transportation system. Such regulatory functions as have been developed for application on this continent are not necessarily directly transferrable to other nations, principally because of differences in road networks, traffic density,

---

[1] Centre for Studies of Law in Action, Indiana University, Bloomington, Indiana, U.S.A.

types of motor vehicles, temperament of drivers, maturation of the driving public, and the cultural use of alcohol. Therefore, because of the extreme variations which exist among nations of the world, and because of the lack of reliable statistics, only nations with high traffic density will be considered, that is, those nations which are heavily involved in the new mobility – the automobile and associated vehicles.

The following discussion attempts to show what is really being done in the law enforcement effort to reduce alcohol related crashes. It also describes criteria for measuring what is actually being done in your own jurisdictions.

About 40 years ago an American jurist (8) studied the role of the American police and courts in the prevention of automobile crashes. He listed four types of offences which were, in his opinion, highly correlated with traffic crashes. These were excessive speed, alcohol, improper lane usage, and following too closely. These crude cause-effect relationships comprise, even today, the basis for classification of our traffic laws.

During the same period about 40 years ago Franklin Kreml[2], then a member of the Evanston, Ill., police department, conceived the idea of using accident records as guides for establishing enforcement priorities. This resulted in the concept of selective enforcement, that is, enforcing the laws regulating driver behavior at the times and in the places where traffic crashes attributable to these violations were happening. This was one of the early attempts to make better use of the resources allocated by police agencies to traffic law enforcement.

It is surely more than coincidence that this more specific type of accident investigation and enforcement generated the first roadside survey to determine the frequency of drinking/driving in the general public as compared with the frequency of occurrence of alcohol in the victims of crashes in the same city. It was this study, carried out in Evanston, Ill. under the aegis of the Northwestern University Traffic Institute and the American Medical Association by Richard Holcomb (3) and reported in 1938, that drew attention to the significance of the alcohol component in highway safety. This study, and others which followed, have been cited heavily in the evolution of laws dealing with the drinking driver.

The use of the term 'law enforcement,' in this paper implies the entire system of apprehension by the police, adjudication by the courts or some alternative institution. The imposing of sanctions, shaded from condemnatory and punitive to therapeutic and educational, are also included.

RESOURCES ALLOCATED TO TRAFFIC LAW ENFORCEMENT

In a typical American city, 10 per cent of police resources are allocated to traffic law enforcement, but included in the violations are such mundane offences as blocking driveways and parking violations. Competition for police and court resources is fierce. Except in special traffic law enforcement agencies such as those which exist in New Zealand and some of our American states that have special highway patrols, the police have never been very enthusiastic about their traffic responsibilities. Public demand to control criminal activities has almost always resulted in placing traffic law enforcement in an inferior position.

This situation is not much different in other nations which I have sampled. Very generally, traffic law enforcement is relegated to the patrol function, which must also respond to criminal complaints. A rule of thumb measure of the enforcement density in urban areas is one patrol policeman per 1,000 population (9).

---

[2] Founder of the Northwestern University Traffic Institute, Evanston, Illinois.

In those nations with a low motor car density, such resources for effective traffic regulation may be adequate. But as the density increases, the problem changes dramatically. Police resources and supporting organizations remain relatively fixed, even as road traffic problems increase. This makes the establishment of priorities even more imperative.

There are several approaches to illustrating the traffic safety problem in a nation. Each has its own use. For instance, from the standpoint of making decisions at the top executive level, the basis might be traffic fatality/population ratio, with possible consideration of the age groups affected. Some of the following illustrations are based on the best information available, which is admittedly imprecise.

Figure 1 shows fatalities due to automobile crashes per million population per year in various nations (10). This type of statistic can be used to illustrate the position of traffic fatalities as a cause of death in competition with other causes. If age of the fatally injured persons is considered, the statistics can have actuarial value. For instance, among the nations shown, the percentage of deaths that can be attributed to automobile crashes for all ages of persons is 2.9; however, in the age group 15 to 24 years, the percentage of deaths which can be attributed to automobile crashes is 41. These percentages must be viewed with caution. The figure of 2.9 per cent is based on a 100 per cent death rate since eventually everyone dies. The figure of 41 per cent is based on the relatively small proportion of persons who die in the 15-24 year age group. However, traffic crashes are the principal cause of deaths in this low age group regardless of these considerations.

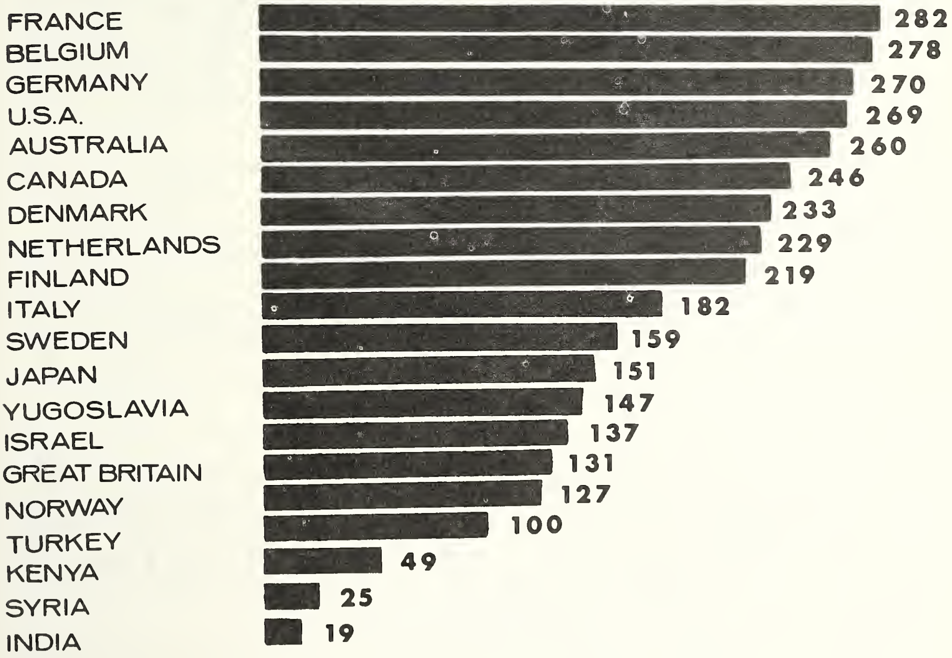
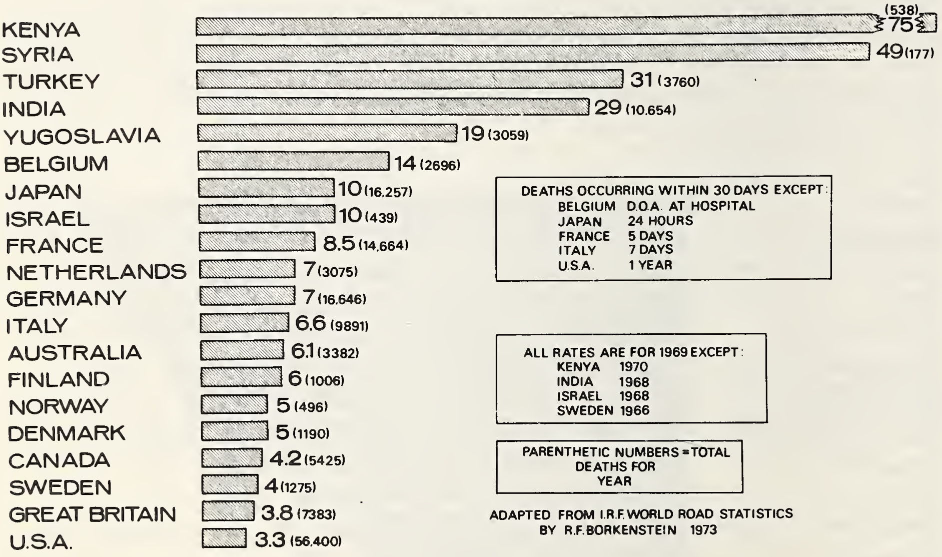


Figure 1 *Fatalities per million population for 20 countries.*

Another approach is to measure fatalities against the task being performed – that is, the ratio of deaths per unit of distance driven. Figure 2 shows the number of highway deaths per 100 million vehicle kilometers in the same nations included in Figure 1 (4). The difference in order is obvious. If a nation has a very low density of motor cars, and very few deaths result from traffic crashes in proportion to the population, the problem will probably be assigned very low priority, even though fatalities per unit of distance driven are high. On the other hand, if the number of highway fatalities competes closely with other causes of death, high priority may be assigned to the problem, even though the rate of death per unit of distance driven is low. For instance, the United States, with a rate of highway deaths of 3.3 per hundred million vehicle kilometers, kills more than 56,000 persons per year from a population of somewhat over 200 million. When considering fatalities per million population we see from Figure 1 that the United States is near the top of the list. A governmental administrator or parliamentary body, charged with allocating resources to relieve public health problems, will consider several factors: first, the problem as competitive with other causes of death; second, the actuarial figures which concern the age groups most highly affected; third, the feasibility and cost of countermeasures; and fourth, but not least important, emotional response of the community.

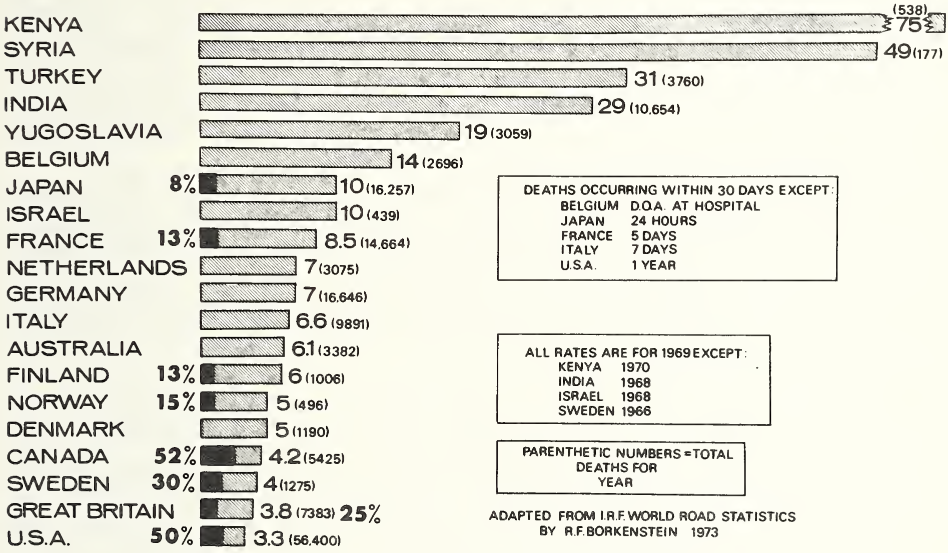


ADAPTED FROM I.R.F. WORLD ROAD STATISTICS BY R.F. BORKENSTEIN 1973

Figure 2 *Fatalities per 100 million vehicle/kms for 20 countries.*

When the problem of highway safety and enforcement of the traffic laws is handed to the enforcement arm of government, the basis of decision changes drastically. The problem now becomes one of attacking the so-called "causes" of fatal crashes that have been translated into traffic law. This means taking a look at the fatality rate or other statistics and deciding, hopefully on valid evidence, which causes as defined by law are contributing most heavily to the problem.

Figure 2 shows that the difference in fatality rates per hundred million vehicle kilometers are enormous. The reasons for these differences are many but we are concerned with the alcohol factor. Figure 3 indicates roughly the percentage of fatalities which were alcohol related in those nations from which I could elicit figures (4). It is now easy to see why Sweden, England, Canada, and the U.S.A. consider the alcohol component of traffic safety such a high priority factor, and why much attention is being directed at countermeasures against the drinking driver. The drinking driver seems to remain as a stubborn residue even when the traffic fatality rate of a nation is very low. It is also quite obvious why other nations, while recognizing that the alcohol factor is about the same for them on a strictly rate basis, still might assign lower priority to this factor because other factors much more susceptible to less expensive countermeasures still must be regulated.



ADAPTED FROM I.R.F. WORLD ROAD STATISTICS BY R.F. BORKENSTEIN 1973

Figure 3 *Percentage of alcohol related fatalities per 100 million vehicle/kms for 8 of the 20 countries.*

It seems that alcohol involvement in fatal crashes is more closely related to the cultural use of alcohol and social stratification of drivers than it is to enforcement and related activities. There is little evidence that law enforcement, adjudication, and sanctions, as currently practised in most nations of the world, have a significant effect. This is without doubt related to the very low level of enforcement, even in those nations of the world which claim to give it great emphasis (1).

To ascertain what is being done about the drinking driver from an enforcement point of view, I collected information from a number of jurisdictions, both in the United States and other nations. On first being asked questions, enforcement authorities often responded with a bit of indignation; but when the actual figures were produced, they had to concede that they fit into an amazingly consistent pattern. The similarity between American and Swedish averages is striking. Police officers in a position to make traffic violation arrests make on the average two alcohol related traffic arrests each year. The range is considerable for individual police officers, but this is the average level of effort being applied to what has been determined to be the number one human factor in traffic safety in America and Sweden. This average is based on dividing the number of police officers in a position to make traffic arrests into the number of arrests actually made per year.

Roadside surveys of occurrence of alcohol in the driving public have shown that when enforcement is at the current level of two arrests per officer per year, and with automobile density what it is in the average congested city today, there are about 2,000 violations for each arrest. A "violation" is a trip from one point to another with a blood alcohol concentration (BAC) of .10% or higher. Thus, in a typical community of one million population, with 1,000 patrol officers making two arrests per man per year, there will be 2,000 arrests and four million violations.

These are very broad cuts, but even if they err by 50 per cent, the problem is still apparent. An arrest rate of 2,000 per year to control four million violations is futile. Even if this rate were tripled or quadrupled or, as usually stated for emphasis, increased 300 to 400 per cent, the attempt would still be feeble. Public deterrence through propagandizing these figures may be effective for a short period, but low perception of actual risk of being caught soon sets in and drinking/driving behavior is bound to regress to the long-term mean. It results in low-yield screening and the basic problem remains untouched, at least in terms of goal achievement – significant reduction of traffic crashes and identification of problem drinkers.

A study conducted a few years ago (2) showed that in a sample of 1,000 subjects from social strata of persons who should have been aware of and influenced by traffic laws, not a single subject was fearful of being apprehended by the police when driving home from a party after drinking too much. This low perception of risk of being apprehended is hypothetically the reason why drinking/driving remains a stubborn residue in those cultures and nations which seem to have reduced traffic fatalities to very low rates.

The big question is, can we afford the resources necessary to achieve general deterrence and at the same time to deal effectively with the individual driver? If the emphasis on therapeutic measures is to be one of our principal goals, it means that we should be screening the corporate whole of the driving population to identify an optimal number of drinking drivers, to classify them as to their drinking problems, and to assign to them the proper sanctioning countermeasures. This might mean increasing our enforcement effort, or at least our apprehension rate by 5, 10 or 15 times our current rate.

The thought of such an increase immediately suggests enormous increases in necessary resources. This need not be the case. A typical American city of one million population makes 325,000 hazardous moving traffic arrests per year. Of these, only three per cent are alcohol related. If patrols were assigned when and where alcohol related offences tend to cluster, the number of arrests need not increase, but the number of alcohol related arrests could increase dramatically. It might mean neglecting some other violations but if alcohol is the highest priority factor, would this not be a logical decision? One important psychological factor must not be ignored. This is the Hawthorne effect (5). *Any* contact with a driver for any violation will affect his entire driving behavior for some period of time. Is it not logical to increase contacts involving the most significant factors and trust that these contacts will do more for drivers than inhibit only the specific acts for which they are cited such as drinking/driving or speeding.

About a year ago I interviewed a group of police officers and asked them how many alcohol related traffic arrests they had made during the prior year. The answers ranged from none to three. I also asked them how many motorists they had stopped for hazardous moving traffic violations whom they thought should have been tested for BAC and possibly put through the formal system. The answers ranged from 75 to 100.

The reasons for this exercise of police discretion are numerous. Cynicism as to the support the charge of driving under the influence will receive in the courts, empathy with the driver, the feeling that sanctions are far too severe, the feeling that this poor individual (poor in the sense of income) is going to be deprived of a substantial part of his livelihood if he loses his driver's license, the cumbersome system employed to handle the drinking driver through the charging, arraignment, and court procedures, are among the reasons given. At any rate, I have tried to set out some of the problems faced by those enforcing the drinking/driving laws, which must be met if we are to be effective in the enforcement of countermeasures.

There are three quantitative terms which can describe the level of activity directed at the drinking driver: maximization, optimization, and minimization of enforcement. Maximization is not practical. It would mean apprehending every drinking driver under every type of circumstance.

From the data I have cited, it is obvious that even in our most ambitious programs we are applying enforcement at a minimal level. The question is, what is optimization?

In the present section of these proceedings Professor Ross used the words "optimum enforcement," and Dr. Havard implied the same. Optimization is a level of enforcement which, coupled with adequate and effective public information, will create a high level of general deterrence. We can hypothesize on the basis of experience in other fields of endeavor that there is a critical point where optimization will be achieved. However, even when this optimum level is reached, it may not be a permanent condition. When the British so-called Breathalyzer Law was enacted and put into action coupled with a very adequate public information program, there was an immediate impact. Dr. Havard called this the "shock" effect. We might say that the level of enforcement, even though very low, coupled with a public information program, was an optimal situation *at the time.* However, the driving public soon adapted to this situation and regression set in. So what is optimal at one moment may not be optimal at the next. We rebel at inflationary prices but soon acquiesce and adapt to them. Thus, optimization is not necessarily a fixed factor.

Possibly, instead of applying a constant level of effort against a factor such as the drinking driver, it would be more effective to use the principle of occasional re-enforcement. Enforcement would reach the optimal level for some period of time. The effect could be measured by counting the frequency of occurrence of excessive BACs in drivers in the traffic flow by employing roadside surveys. When the effect of enforcement would become quantitatively evident and consistent with pre-determined goals, enforcement could be relaxed until a point of undesirable regression would be reached, when another re-enforcement could be imposed until the desired suppression of the frequency of occurrence of alcohol would again be evident through a roadside survey. This would be a continuous process. Under these conditions a massive amount of the resources allocated to traffic law enforcement could be used during the re-enforcement periods. It would release a large segment of police resources to be used for other purposes during the intervals between the re-enforcement periods. It is hypothetically possible that after a time, the life style of drivers regarding their combining of drinking and driving would be permanently altered.

Our current traffic law systems are based on principles more than 40 years old. They were conceived at a time when people, motor cars, and highways were very different to what they are today. They were conceived when transportation technology was in its infancy. They were conceived before the behavioral and social sciences became involved in the field.

As in any profession it is imperative to re-examine the tools with which we work from time to time to see whether or not they comprise the best of all worlds at the moment. If they do not we must change. Perhaps the Alcohol Safety Action Projects of the U.S. Department of Transportation have been the first real attempt to systematize thinking in this area. Our approach has been largely one of catching a few fish from the sea of drunken drivers and making horrible examples of them. This approach apparently has not been successful. Perhaps we should be looking at the deterrent effect through optimal enforcement as our only primary means of reducing driving while impaired by alcohol, and at the same time identifying an optimal number of problem drinkers who are not only problems in highway safety, but problems in their homes, on their jobs, and in other areas of their lives. It is the only process by which we can obtain legal coercive control on such individuals. This gives meaning to the task. If effective feedback can be provided to the patrol police officer, to the courts, and to the supervisors of sanctions, would this not provide job satisfaction? Would not reduction of frequency of alcoholic drivers, measured by roadside surveys, give added meaning to the activities of the patrol officer? Would not the principle of task variety enrich the police job by reducing monotony? There is nothing more boring than routine police patrol. Would this not increase the perceived omnipresence of the police by sub-populations engaged in other deviant activities proscribed by laws which could also receive occasional emphasis enforcement through such a system of resource allocation?

Apparently we do not have the answers to these questions. To my knowledge such systematic usage of police and court resources has never been employed. All this requires a change in thinking. We must be concerned about the individual driver and at the same time about the public safety aspects as they affect the entire community.

This is a new methodology for the field that requires flexibility in thought. Introducing change into law enforcement and the traditional courts is difficult, but we must always be aware of the implications of an old Chinese proverb:

The willow that bends is stronger than the oak which resists.

REFERENCES

1. American Medical Association. *Alcohol and the Impaired Driver.* Chicago, 1970. Chapter V.
2. Borkenstein, R., Klette, H. *The Perception of DWI Laws: A study of the General Awareness and the Attitudes of Public and Official Groups Toward the Drinking Driving Laws.* U.S. Government Printing Office, 1971. U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, D.C. Contract No. DOT-HS-034-1-050.
3. Holcomb, R. L. Alcohol in Relation to Traffic Accidents. *Journal of the American Medical Association*, 111, 1076 (1938).
4. International Road Federation. *World Road Statistics.* 1972 Edition. Geneva, Switzerland and Washington, D.C.
5. Maier, N. *Psychology and Industry.* Houghton-Mifflin Co. Boston, 1955.
6. Newspaper Enterprise Association. *The World Almanac.* New York, N.Y. (population information), 1974 edition.
7. Owen, W. *Strategy for Mobility*. The Brookings Institute, 1964.
8. Warren, G. *The Traffic Courts.* National Conference of Judicial Councils. Boston, Little Brown, 1942.
9. Webster, J. A. *The Realities of Police Work.* Kendall/Hunt, Dubuque, Iowa, 1973.
10. World Health Organisation. *World Health Statistics Annual*, 1967.

The Effectiveness of Drinking-and-Driving Laws in Sweden and Great Britain

H. Laurence Ross [1,2]

The most important single human-factor contribution to motor vehicle fatalities, especially in societies with mature automobile-centred transport systems, is driving while under the influence of alcohol (27). This fact is viewed as a major challenge to the creation and use of legal sanctions. Throughout the world, important hopes and huge investments currently rest on the proposition that by threatening the drinking driver with criminal punishments, the legal system can deter at least a significant portion of the driving population from combining their driving with the consumption of alcohol.

The proposition is based upon 'common sense' considerations. Drinking alcohol and driving a car are usually the results of voluntary decisions, and 'we all know' that in making our voluntary decisions we calculate the costs and benefits of various alternatives to the best of our ability. The threat of fines, loss of drivers' licenses, and even imprisonment is assumed to affect the decisions of many drivers as to whether they consume alcohol and when. Of course, persons who drive while affected by alcohol also take on the risk of accidental injury and death, but they may discount this risk, especially at relatively low levels of alcohol consumption, and feel that the probability of an injury during a given trip is realistically quite remote, even at relatively high levels of alcohol consumption. Thus, there is reason to expect that supplementing the risk of injury with the risk of criminal punishment would have beneficial social consequences through the deterrence of drinking-driving. However, there is little evidence currently available concerning the empirical validity of this expectation.

In this paper I shall describe the development of the legal response to the problem of the drinking driver, from a lack of awareness, to the enactment of what I term "classical" laws, to the relatively recent *per se* or fixed blood alcohol level laws. I shall describe the problems met by classical legislation, and the rationale with which *per se* laws were proposed to ameliorate these problems. Specific attention will then be given to a) the effect of the British Road Safety Act of 1967, where evaluation research confirmed the existence of an important effect of the legislation on deaths and injuries in alcohol-related motor vehicle crashes, and b) the Swedish legislation of

---

[1] Professor of Law and Sociology, University of Denver, College of Law, Denver, Colorado, U.S.A.

[2] Those parts of the paper addressing Scandinavian experience are drawn from a research project funded by a grant from the Insurance Institute for Highway Safety, Washington, D.C., U.S.A.

1934, 1941, and 1959 (and similar Norwegian law). However, despite widespread belief to the contrary, modern techniques of evaluation can find no evidence that the latter have been effective. The contrasting findings on the effectiveness of *per se* law lead to speculation on the conditions that produce its deterrent effect in some cases.

CLASSICAL LAW

In the early years of the twentieth century, the automobile was fitted into a legal framework developed for pre-existing means of transportation, exemplified by the horse and buggy. Although it appears that injuries were commonplace in the days of animal-powered transportation, they seem to have been regarded with relatively little concern, perhaps because they were less serious in their consequences and also because they occurred in societies that had not yet conquered a variety of more menacing causes of morbitidy and morality. The question of drinking in combination with driving does not seem to have been a source of special legal concern in most countries during the early years of the automobile. In both Sweden and England, the countries to be discussed more specifically in this paper, it was not until 1925 that laws were passed specifically forbidding an individual to operate a motor vehicle while intoxicated. The British law merely applied to the automobile an older prohibition against being "drunk in charge" of horses and steam engines.[3] The Swedish law prohibited driving "while clearly under the influence of strong drink".[4]

This wording initiated a period of what I term classical drinking-and-driving legislation in both countries. In both cases, it was soon recognized that a considerably smaller amount of alcohol influence than denoted by this wording could be relatively hazardous when combined with driving, and a series of subsequent acts attempted to penalize these lesser degrees of alcohol influence. Successive British definitions of the offense were: "being under the influence of drink or a drug to such an extent as to be incapable of having proper control of a vehicle",[5] being "unfit to drive through drink or drugs",[6] and driving when the "ability to drive properly is for the time being impaired".[7] In Sweden, the definition of the offence was changed to being ". . .so impaired by strong drink that it can be assumed that he lacked the ability to control his actions (or) his automobile. . .".[8]

However, despite the manipulations of language, as the number of motor-vehicles increased and related fatalities and injuries became more visible, dissatisfaction mounted with respect to classical laws. It became increasingly clear that people were continuing to drive when impaired by alcohol and that, despite the statutory reformulations and despite increasing penalities, the legal system was not working as expected in this area.

I have previously discussed some of the sources of difficulty in applying classical law under three headings: problems of identification, problems of judgment, and problems of sympathy (17). In brief, problems of identification are experienced in identifying alcohol-influenced driving through traditional police patrol techniques. As the statutes came to refer to increasingly lesser degrees of alcohol influence, these problems increased. Drivers may be impaired by alcohol to a dangerous and legally prohibited extent, yet give no cues to stationary or moving police officers. Even in

[3] British Licensing Act of 1872.

[4] Swedish Statute Book (SFS), 1925: 151.

[5] British Road Traffic Act of 1930.

[6] British Road Traffic Act of 1960.

[7] British Road Traffic Act of 1972.

[8] SFS, 1930: 284.

face-to-face contact, where the odor of drinking on the breath is a possible cue, police often fail to make identifications of drinking drivers (24). Problems of judgment inhere in the language of all classical statutes because of the imprecision of such concepts as intoxication, alcohol influence, and the like. Even expert judgments on these matters are notoriously unreliable (7). Problems of sympathy are met where there is a bias on the part of the decision-maker against the law or in favor of the defendant, leading to acquittal where an unbiased court would convict. This bias in drinking-and-driving cases may be related to the suspected broad prevalence of the offence and the lack of demonstrated harm in the individual case as well as underestimation of the amount of alcohol consumed by the accused.

In an attempt to overcome the problems of judgment inherent in classical legislation, both England and Sweden, at different times, made provision for blood tests to be administered to those accused of drinking and driving. In Sweden, this innovation came about in 1934, and it was coupled with legislation making prison the standard punishment for the offense.[9] In Britain it was not until 1962 that similar legislation was passed.[10] In both cases it seemed that little benefit was obtained from combining blood alcohol testing with classical legislation. The Swedish Parliamentary Ombudsman's Annual Report for 1939 contained data on the experience in Stockholm under the 1934 law. Where blood alcohol concentration (BAC) was less than 1.50 *pro mille*,[11] charges were filed in only 29 of 132 cases, and only 7 persons were found guilty. With blood alcohol in the very high range of 1.5 to 2.0 *pro mille*, 50 of 196 people were not charged, and an additional 30 were found not guilty. There were records of not guilty findings (being appealed) at the extreme concentrations of 2.09 and 2.97 *pro mille*. More than 25 years later, the British were surprised to find similar results for the similar provisions of the Road Safety Act of 1962 (8).

PER SE LAW

The Swedish and British refinements just discussed were made possible by analytical methods developed in Scandinavia in the 1920s whereby small blood samples could be used to yield reliable estimates of BAC. These same methods also permitted a more radical development in drinking-and-driving legislation, the *per se* law. This type of law defines the prohibited behavior in terms of the blood test, i.e., it becomes illegal *per se* to attain a BAC over a fixed maximum. Attainment of the concentration is measured by a scientific test, eliminating any need to demonstrate "drunkenness", "intoxication", "influence", etc. Such a law aims directly at solving problems of judgment and indirectly at problems of sympathy which can bias judgment. A common feature of these laws is fixed penalties which automatically follow upon conviction, thereby further controlling sympathy.

The prototype and first historical example of such a law was the Norwegian legislation of 1936. Norway had had classical legislation from 1912, with prison being the prescribed sanction from 1926.[12] In 1935 it was stipulated that blood tests could be taken.[13] From July 16, 1936, Norwegian law equated being under the influence of alcohol with having a BAC of 0.5 *pro mille.*[14] The legislation provided for an almost automatic prison sentence of a minimum of 21 days.

---

[9] SFS, 1934: 247.

[10] British Road Traffic Act of 1962.

[11] Parts per thousand, in terminology used in Scandinavian writing. 1.50 *pro mille* is approximately equivalent to 0.15 per cent by weight in American terminology, or 150 mg/100 ml in British terminology. This report will utilize Scandinavian terminology, which can be understood by readers accustomed to other notations by shifting the decimal point.

[12] British Road Traffic Act of 1912; British Road Traffic Act of 1926.

Sweden adopted a *per se* law in 1941, during World War II. A strong temperance movement in that country, as in Norway, provided momentum to pass such a law at a time when there was still considerable dispute among professionals concerning the accuracy of available blood tests and the amount of impairment generated at various blood alcohol concentrations. Differential treatment of apparently similar offenders under the 1934 legislation was an additional reason motivating early acceptance of *per se* legislation.[15] The principal differences from the Norwegian law were that the *per se* level was set at 0.8 *pro mille*, and prison became the standard penalty only at 1.5 *pro mille.*[16] The law was modified in 1957, setting the *per se* level at 0.5, the same as in Norway.[17] The minimum prison sentence in Sweden is one month.

The Road Safety Act of 1967 introduced the *per se* legislation into Britain. The criterion is a BAC exceeding 0.8 *per mille*. Unlike Scandinavia, Britain does not exact a prison sentence for this offence, but a year's license suspension is mandatory.

The apparent success of the British *per se* law, discussed below, coincident with renewed concern over alcohol-related traffic incidents, has produced an international legislative revolution in the past several years. The European Conference of Ministers of Transport recommended *per se* legislation on a continent-wide basis in 1967, and at present such legislation exists with varying limits in Austria, Britain, Switzerland, Holland, France and West Germany, along with Norway and Sweden. *Per se* legislation has also been enacted in the United States, Canada, Australia and New Zealand, and many countries of the Eastern bloc. In other countries, judicial practice has resulted in convictions at fixed BACs. Examples are Belgium and Denmark (11).

The Effect of the British Road Safety Act

Immediately following the enactment of the British Road Safety Act of 1967 there occurred a sharp drop in highway casualties, which was generally attributed to the effect of the legislation. Although the initial claims were based on shaky reasoning, examination of the experience with the aid of the modern and sophisticated tool of interrupted time-series analysis confirms that this *per se* law did in fact sharply reduce fatalities and injuries in Great Britain at the time of its inception (17). The most persuasive evidence is provided by the complete coincidence between the inception of the legislation and the reports of reduced casualties, and by the fact that casualties on weekend nights (when alcohol is most likely to be involved in crashes) were sharply reduced while those during weekday commuting hours were unaffected. These data are reviewed in Figures 1, 2 and 3, respectively (17). It is noteworthy, however, that the curves in Figures 1 and 2 show not only a statistically significant drop associated with the Act, but also a change in slope following this drop that would tend, other things equal, to return matters to the *status quo ante* in the near future. In other words, there is reason to believe that the effect of the Road Safety Act in reducing highway casualties may be temporary. This interpretation of the changing slope of the time-series curves gains support from data on the BACs among highway fatalities, which declined from 1967 to 1968, but had returned to its previous level by 1971 (17).

---

[13] Law of June 21, 1935, No. 4.

[14] Law of June 16, 1936, No. 4, on "the abstinence from alcohol for persons in certain conditions."

[15] This criticism is apparent in the 1939 Annual Report of the Parliamentary Ombudsman to the Riksdag.

[16] SFS, 1941: 397.

[17] SFS, 1957: 355.

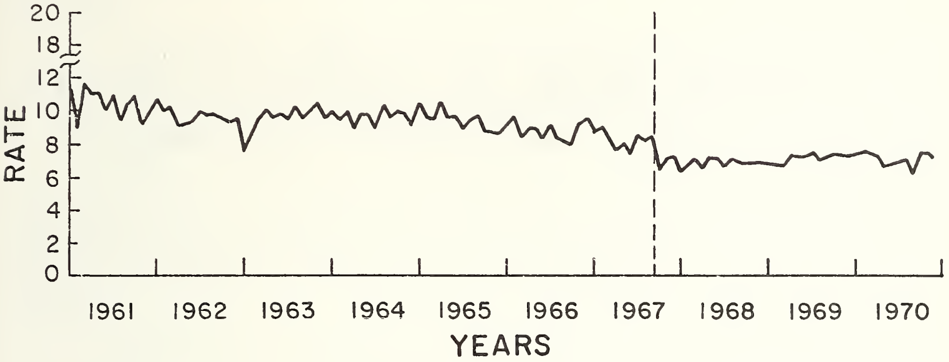


Figure 1 *Fatal road accident rate for England and Wales, corrected, 1961-1970. Source: Reference (17) figure 7.*

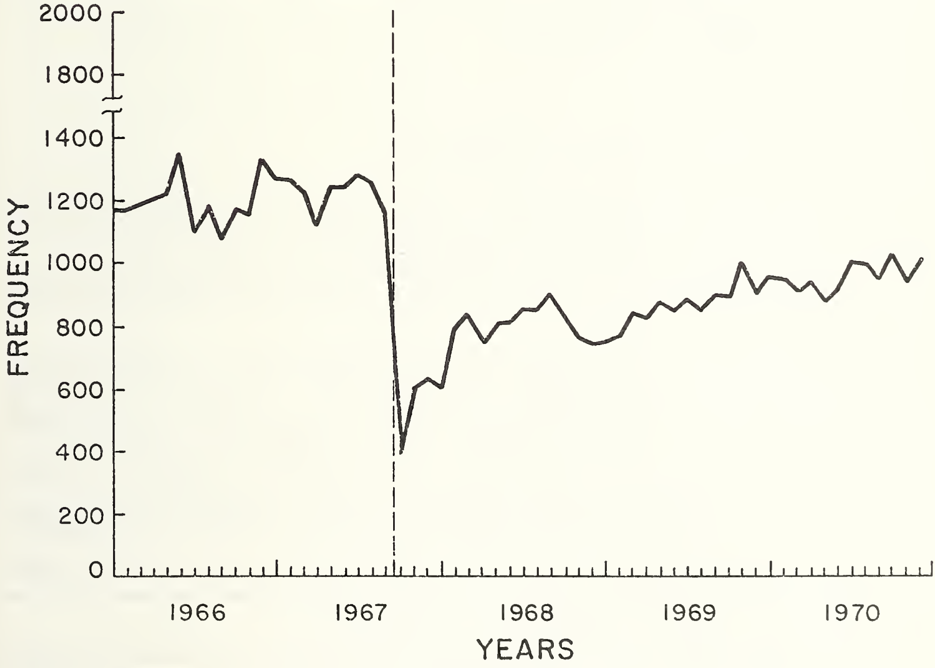


Figure 2 *Road-accident-related fatalities and injuries in England and Wales, 1966-1970, weekend night hours. Source: Reference (17) figure 10.*

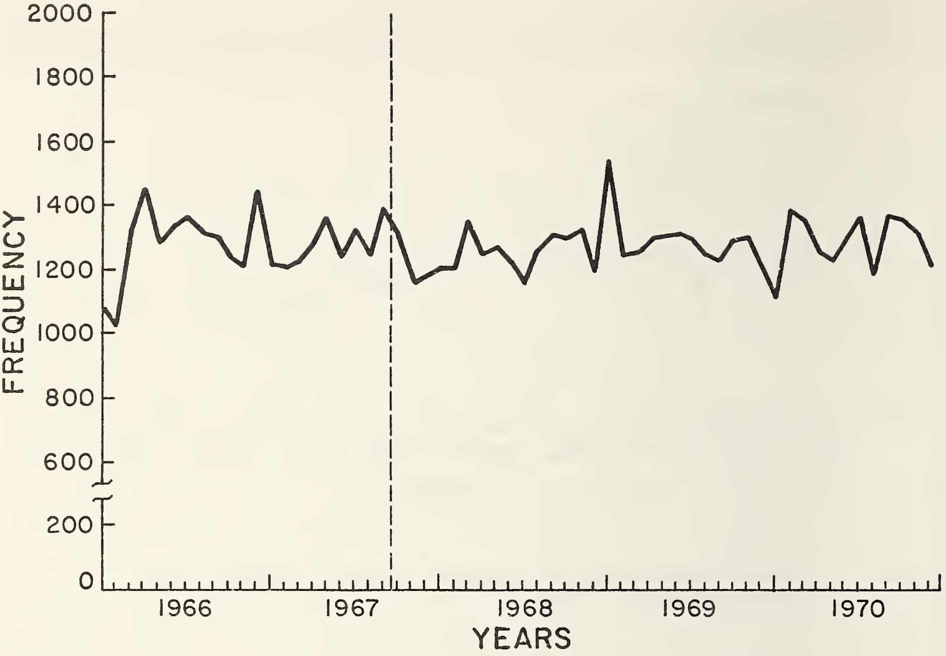


Figure 3 *Road-accident-related fatalities and injuries in England and Wales, 1966-1970, weekday commuting hours.*
Source: Reference (17) figure 11.

Claims Concerning Scandinavian Legislation

The successful British Road Safety Act was modeled on the earlier Scandinavian legislation, which is widely believed to have demonstrated the effectiveness of *per se* laws with harsh penalties in reducing highway casualties. At this point, I shall summarize the claims made and report the results of efforts to verify the effectiveness of these laws.

Belief in the deterrent effectiveness of the Swedish legislation is almost an article of faith among Swedish traffic experts, parliamentarians, academics, and others concerned with the drinking-and-driving laws. In recent years questions have been raised concerning the need for mandatory imprisonment in achieving this effectiveness, a matter which led to a large-scale review by a Parliamentary Commission of Inquiry between 1967 and 1970 (24). The Commission, in fact, recommended abolition of mandatory prison in favor of judicial discretion to substitute probation and treatment. However, the Commission did not seriously question the assumption that deterrence was being achieved under the present law; they merely argued that the proposed change would not be likely to diminish the deterrent effect.

I spent three months in Scandinavia in the spring of 1974 searching for scientifically acceptable evidence of the effectiveness of the Swedish and also the Norwegian *per se* laws, and have to report that the belief in their effectiveness seems to rest upon scientifically unacceptable evidence. The more systematic arguments, which I find unconvincing, come down to the following:

1. As noted by the Parliamentary Commission of Inquiry, the rate of drinking-and-driving violations over time, when corrected for an increasing vehicle population, is relatively constant. Although the Commission's report mentions this fact without much comment, one interpretation finds this constancy in the face of broader definitions of the offence (the 1957 law and a few other minor extensions) to be evidence of deterrence:

> . . .*it might be noted, however, that the comparative crime frequency seems to have been kept under control in Sweden. The pro mille legislation and the increased supervising possibilities that this rule provides has probably been a contributing factor to this comparatively favourable development.* (5, p. 304).

A Parliamentarian, impressed that the violation rate remained relatively constant even though there was an increasing rate of alcohol consumption and a repeal of some legislation restricting the sale and distribution of alcoholic beverages, provides another example:

> *That the relative frequency of traffic intemperance has not increased seems to show, I think, that it is really possible, at least to some extent, to control the behaviour of people in this respect by means of legislation. No doubt the severe special legislation against intemperance in road traffic has been an important reason why matters have not developed in a more unsatisfactory way.* (16)

I do not find these interpretations to be particularly impressive. The constance of the violation rate would be evidence in favor of the deterrence hypothesis only if there were some way of judging what the rate would be in the absence of the specific, severe, *per se* legislation. This question can be, and has been, approached by the interrupted time series analysis described below. The opinions cited above, however, are not based on any such evidence. That diametrically opposed conclusions can follow from the data is indicated by the official opinion of the Swedish temperance motorists' Association that the doubling of *absolute* numbers of arrests from 1950 to 1967 indicates that the problem of drinking and driving is *not* under control (26).

A further problem in the interpretation of violations is the questionable relationship of the official data to the underlying behavior of drinking and driving. All reputable estimations of the "dark figure" in Sweden (13) and elsewhere place the number of actual violations of drinking and driving laws at many times the number of arrests and violations known to the police. Furthermore, the relationship certainly varies from jurisdiction to jurisdiction and from time to time (6), making valid comparisons very difficult. In sum, little credence can be placed in this line of argument for the deterrent effect of the Swedish law.

2. A different argument concerns the proportion of alcohol-involved drivers in various kinds of crashes. The argument has been stated as follows:

> *The recently presented Swedish report concerning the legislation about drunken driving calculates that of the total number of fatal casualties in road accidents in Sweden between 10% and 30% occur in accidents involving drivers under the influence of alcohol. Even if the proportion of drivers under the influence of alcohol is disturbingly high the fact is that it seems to be about 20% lower than in countries with more liberal regulations. If drunken driving in Sweden were to deteriorate so that the proportion of fatal accidents*

> *involving alcohol rose from 30% to the "international" level of 50%, it is possible to work out mathematically that the total number of fatal accidents in this country per year would increase from the present figure. . . It is reasonable to assume that thanks to our relatively stringent and consistent legislation nearly 500 lives are saved on our roads every year.* (20)

Again, the argument has weaknesses. The report of the Parliamentary Commission of Inquiry cited here contained a survey based upon a sample of only 40 per cent of the drivers killed in crashes in Sweden in 1968 (25). Of the 200 blood-tested drivers, 63 had blood alcohol exceeding 0.5 *pro mille*. The lack of representativeness of the sample made it impossible for the Commission to be specific concerning the role of alcohol in fatalities, and the 30 per cent figure cited above is not necessarily a good guess as to the true number of drivers affected. Incompleteness of the sample also hinders interpretation of the Voigt study in southern Sweden, where an attempt is being made to analyze the blood of all who die in motor vehicle crashes in the region. A recent report of this study states that 8 of 46 tested drivers in multi-vehicle collisions and 10 of 38 tested drivers in single-vehicle crashes had BACs of more than 0.5 *pro mille* (10). However, in both these comparisons there were in fact considerable numbers of untested drivers. Studies of patients admitted to Swedish hospital emergency rooms because of motor vehicle crashes suggest that the figures mentioned above may be too conservative. A survey of such admissions to Stockholm's largest hospital in the winter of 1951-52 found that 32.4 per cent had some alcohol in their blood (3). Currently, a similar study is being done at the hospital in the provincial city of Linköping, and it is informally reported that of 350 admissions of injured drivers in 1972 and 1973, 20 per cent had more than 0.5 *pro mille* of blood alcohol. Since alcohol is more often involved in fatal accidents, these findings for the injured suggest that the estimates for fatalities given above may be on the low side.

Moreover, even accepting the figure of 30 per cen as a guess for the number of alcohol-related highway deaths in Sweden, the comparison with an 'international' rate is not meaningful, on two grounds. On the one hand, a better comparison would be alcohol-related crash involvement per unit exposure – per vehicle or per mile. This would rule out the possibility that the 'low' association of alcohol with accidents is merely the reflection of the high association of other factors with crashes in Sweden. If weather and road conditions, for instance, cause an unusual number of crashes in Sweden, a low proportion of alcohol-related crashes would be expected without any legal deterrence of drinking and driving. On the other hand, even if the association of drinking and driving in Sweden is in fact restrained, this may perhaps be due to factors other than the law, for instance general cultural attitudes, restrictions on the availability of liquor, peculiarities of access to liquor and cars, between the social strata.

3. Another line of argument for the deterrent effect of the law cites the strong support which he law receives in public opinion polls. True, a variety of opinion surveys in Sweden and Norway show support for punitive law concerning drinking and driving. One study by the Swedish Institute for Public Opinion in 1970 found 63 per cent of a random sample supporting the prison sentence as it stands, and an additional 27 per cent believing that the punishment should be more severe (20). Swedish tax authorities found that the public was more willing to imprison drunken drivers than any of a variety of tax cheats, smugglers, burglars, or auto thieves (23). In Norway, a very recent study found drunken driving to outrank such crimes as burglary and forgery in public estimation of seriousness (2).

There are reasons to take this public opinion material with a grain of salt. The author of the tax study stated in an interview that he felt the condemnation of drunken driving in his study merely reflected the widespread knowledge on the part of his informants that the behavior was in fact punished by imprisonment. My interviews with policemen, lawyers, judges and prisoners frequently obtained opinions that the drinking drivers were not 'real' criminals, and that prison was not an appropriate sanction (15). Furthermore, in the light of the social science truism that attitudes and behavior may diverge widely, even if these attitudes are held with conviction, it is not possible to argue forcefully that people apply the corresponding principles to their own behavior and in given instances refrain from drinking and driving.

4. A final argument made for the deterrence hypothesis cites the predominance of unusual sorts of people among those convicted of drinking and driving. There is good evidence that the convict population contains large numbers of people with histories of alcohol problems and of general criminality, as well as disproportionate numbers of young people. Studies for the Parliamentary Commission of Inquiry found that 64 per cent of first degree drunk driving convicts had prior records of alcohol problems and more than one-third were driving without licenses (8, 21). A more recent study at Uppsala University showed 33 per cent of a group of drinking and driving convicts to have had registered alcohol problems and 63 per cent to have had criminal records (including convictions for drunkenness). Moreover, the blood alcohol concentrations of those convicted tended to be quite high (1).

Supporters of the deterrence hypothesis argue that figures like these reveal an absence of 'normal' drinkers in the drunk driving population, and conclude that the 'normals' have been deterred. However, one can again question the logical leap that attributes the facts to the effect of the law. In the classical legal environment of the United States in the 1960s, the same kinds of findings were being reported. According to the 1968 Alcohol and Highway Safety Report more than 80 per cent of men arrested for driving while intoxicated were known to community service agencies for reasons related to the use of alcohol, yet this fact was not taken as evidence for the success of American law in dealing with drinking and driving (27). Furthermore, the high BACs noted in Sweden (and in fact universally) among those convicted of drinking and driving reflect in part the limitations of the abilities of policemen in detecting drivers with law BACs. This matter has led to the Parliamentary Commission recommendation, strongly supported by the police, that it be legal to give breath tests to anyone stopped at a roadblock regardless of visible evidence of intoxication.

Interrupted Time-Series Analysis of Scandinavian Data

My search of Scandinavian sources for satisfactory evidence concerning deterrent effects of the drinking-and driving legislation led to the conclusion that such evidence was not available. However, if the legislative innovations in Scandinavia produced an effect on the order of that produced in Great Britain, it should be possible to view that effect in the time series of motor vehicle casualties. There were three important changes in Swedish law: 1934, when blood tests were incorporated into the law and prison was established as a routine punishment; 1941, when the *per se* legislation was enacted; and 1957, when the *per se* limit was lowered from 0.8 to 0.5 *pro mille*. The Norwegian legislation was enacted in one sweep in 1936, with a tightening of some details in 1959. It should be noted in advance that there are problems in employing this method in Scandinavia that were not met in Britain. First, analysis of innovations as early as the 1930s runs into the fact that statistics related to the automobile were poorly developed through the decade. Even the admirable statistical institutions of Sweden did not begin to develop special automobile-related series until 1935, and for the first several years the recording methods appear to have been regarded as experimental, producing difficulties in tracing similar data from year to year. I have utilized indirect and local data series for the analysis of the legal changes of the 1930s, but these series may be less accurate and are certainly more subject to unexplained fluctuations than the subsequent national series.

The Swedish law of 1941 presents special problems for interrupted time-series analysis because of its coincidence with World War II, involving gasoline rationing and the prohibition of nearly all civilian traffic, along with shortages of alcoholic beverages. Wartime conditions may also have resulted in considerable inaccuracy in the measurement of such phenomena as motor-vehicle-related crashes and render problematical assumptions concerning relationships between vehicle registrations and mileage. The changes of the 1950s took place at a much more favorable time for analysis, but it can be argued that these changes were, in both Sweden and Norway, relatively minor and unlikely to produce important results in casualty rates as compared with the earlier innovations. With these caveats in mind, the data may be reviewed.

Figure 4 presents the number of fatal road accidents in Sweden from motor-vehicle statistics of 1935 and 1973. The 1934 legislation cannot be evaluated from this curve, but it is clear that neither the 1941 nor the 1957 legislation is associated with any marked change in fatalities, even though fatal crashes would be expected to reflect the deterrence of drinking and driving more than less serious crashes. In Figure 5, the same data are presented on the base of number of registered vehicles, which fell greatly during the War. This correction gives the curve a different form, but it provides no further support for the notion of a deterrent innovation in either year. A similar analysis of non-fatal and of total reported crashes, not presented here, yields the identical picture, as do analyses of numbers of persons killed and injured.

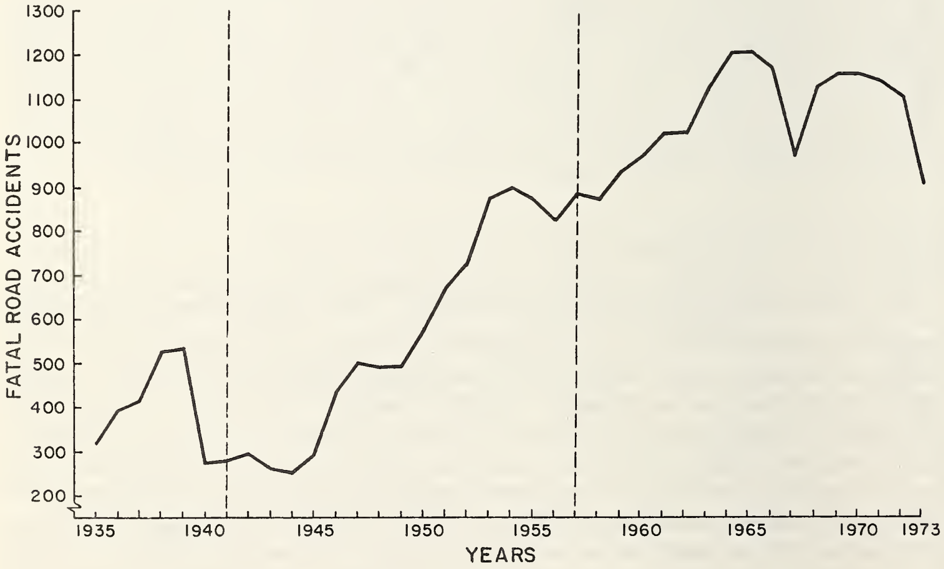


Figure 4. *Fatal road accidents in Sweden, 1935-1973.*

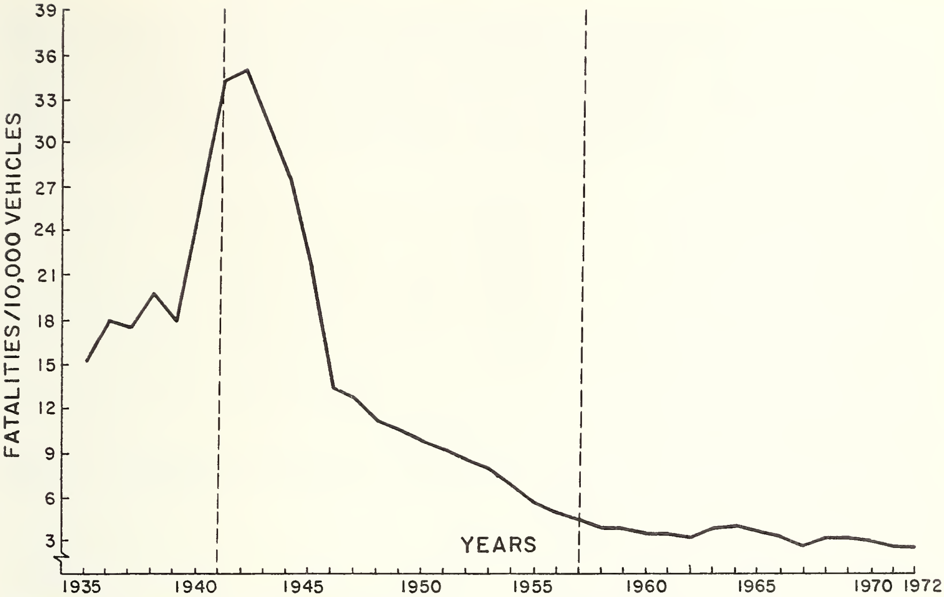


Figure 5 *Fatal road accidents in Sweden per 10,000 registered vehicles, 1935-1972.*

A longer data series for motor vehicle related fatalities is provided by coroners' statistics, where the cause of death is determined to be a "traffic accident". This series is presented in Figure 6, yielding the same negative conclusion concerning the 1941 and 1957 laws and showing in addition a lack of support for the expectation of a decline in fatalities following 1934.

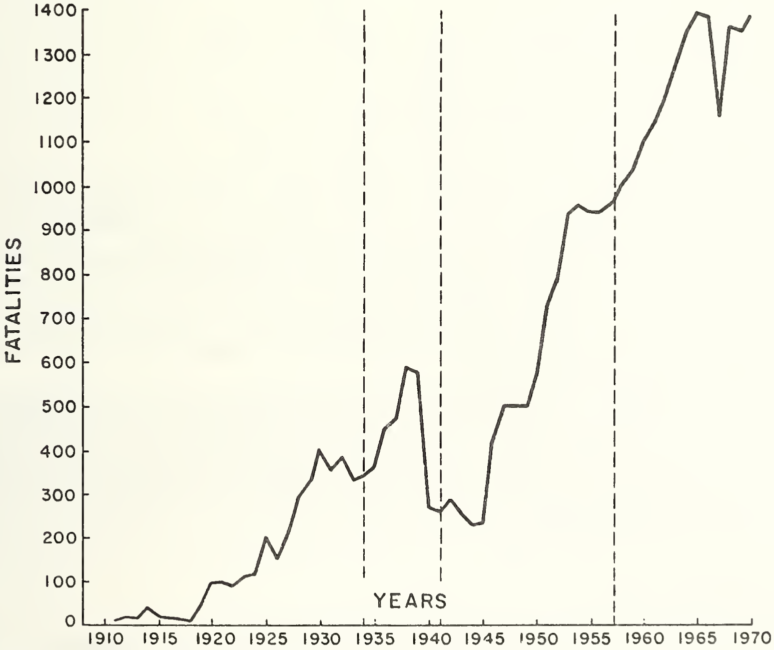


Figure 6 *Traffic fatalities in Sweden – Coroner's statistics, 1911-1970.*

Another perspective on the 1934 legislation in Sweden can be obtained from the series of fatalities in "automobile collisions" in Stockholm, which is available for the years 1924-1938 and is presented in Figure 7. Although there is a drop in 1935 as predicted on the basis of the deterrence hypothesis, it is clear that this is easily ascribed to the large change variation that characterizes the series for a small jurisdiction.

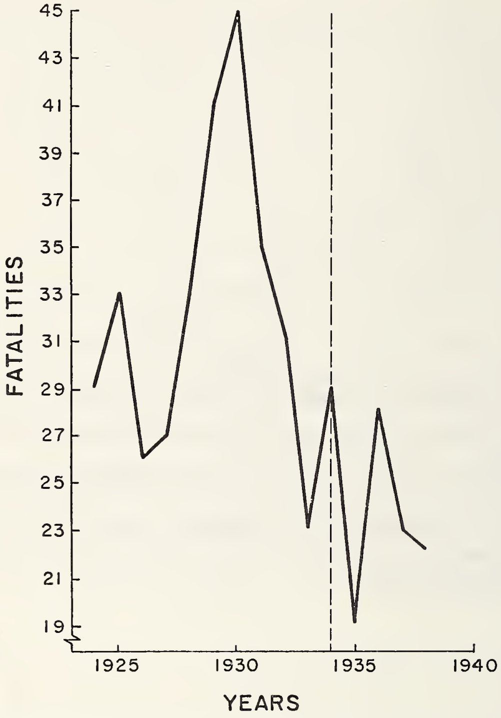


Figure 7 *Traffic fatalities in Stockholm (collisions only), 1924-1938.*

Figure 8 presents data on fatalities in "non-collision traffic accidents" which are particularly likely to involve alcohol influence. The changes surrounding the 1941 and 1957 laws are quite small and statistically insignificant, again failing to confirm assumptions of deterrent effectiveness. Similar analyses were performed on data, available from 1956 onward, concerning fatalities caused by crashes during evening hours (4 p.m. to 4 a.m.) and on Saturdays and Sundays. The curves show no significant response to the 1957 Swedish legislation.

Norwegian data seem to tell the same story with respect to the similar legislation in that country. Most series for Norway begin in 1939, but coroners' records concerning violent deaths ascribed to motor vehicles are available for the period encompassing the 1936 law. These data are presented in Figure 9, and show no evidence for an effect of the legislation on these deaths.

The Scandinavian Myth

The weakness of the arguments offered for the deterrent effects of the Swedish and Norwegian laws on drinking and driving, coupled with the failure of interrupted time-

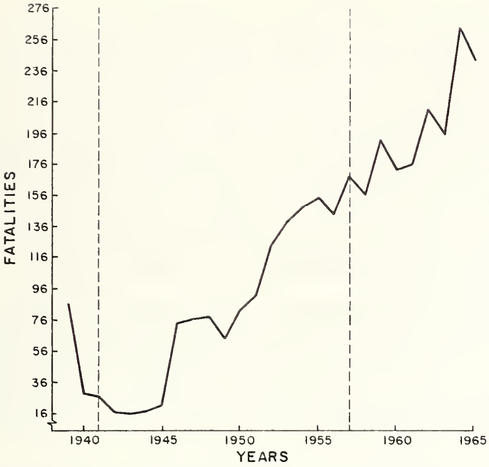


Figure 8 *Fatalities in non-collision traffic accidents in Sweden, 1939-1965.*

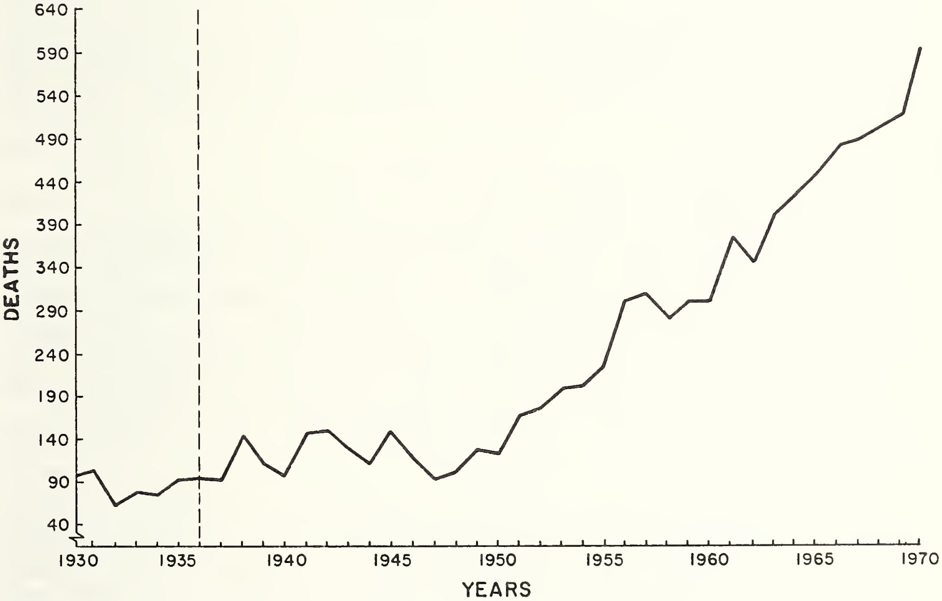


Figure 9 *Deaths caused by automobiles in Norway, 1930-1970.*

series analysis to produce any evidence in favor of the deterrence hypothesis, leads to the conclusion that the international faith in the efficacy of the Scandinavian laws on drinking and driving is without firm foundation. Although the analysis presented here does not disprove the deterrence hypothesis, neither the time series nor the other arguments presented offer convincing confirmation for the hypothesis in the Scandinavian context. The state of the matter is exactly as suspected by William Haddon, Jr., in a 1970 speech:

> *. . .whenever countermeasures are mentioned the subject of their various varieties in Scandinavia comes up, often elaborated with personal anecdotes*

> *and subscription to the folklore of their presumed efficacy. Nonetheless, there is much evidence that crashes due to abusive drinking are commonplace in Scandinavia, and there is no adequately quantitative scientific evidence as to the precise effect of the countermeasures employed* on crash reduction, *as opposed to police, administrative, and judicial activity. Most of the precise types of data given in the* Alcohol and Highway Safety Report *are, for example, unobtainable in any part of Scandinavia. It is time they were.* (42, p. 14).

In rare agreement with this position is a paper by Melvin Selzer with the title, "A Scandinavian Myth?" in which he notes that:

> *. . .one hears and reads constantly of the "effective legislative programs" of the Scandinavian countries in regard to drunk driving. Even American experts on legal sanctions frequently applaud Sweden's relatively direct methods. Meanwhile, hard evidence that the Swedish way is even remotely successful has not been forthcoming.* (19)

As noted above, the methodology that so strongly supported the effectiveness of the British legislation is handicapped in dealing with these older laws, but it is disappointing that the latter did not receive even ambiguous support in my investigation. I should like to note my feeling that the Scandinavian governments have a duty to the thousands of persons imprisoned each year for drinking and driving to demonstrate convincingly that some social benefit is being achieved in return for their distress and inconvenience (28).

Deterrence and "Per Se" Legislation

My investigations have shown support for the proposition that the British *per se* law, accompanied by the sanction of mandatory loss of the driver's license, deterred drinking and driving in that country following 1967, at least temporarily. There is no such evidence that Swedish or Norwegian laws produced a similar effect, even though violation bore the more severe penalty of a prison sentence in addition to even more lengthy license suspensions. Studies of some other instances of *per se* legislation, most notably that in Canada (4), also report negative findings. This situation begs for consideration of the characteristics of the British law that appear to have made it peculiarly effective.

The key does not seem to be in knowledge of the law. Although the formal provisions of the British law were known in considerable detail by most drivers, the same is true for the Scandinavian laws, and also for the Canadian. Nor would there seem to be relevant differences in the matter of public support which, as noted above, is very great in Scandinavia.

As the penalty associated with the British law is much less than in Scandinavia, the degree of the threatened punishment would not seem to be at issue. I have reviewed elsewhere the experience of a 1950 law in Finland which raised the maximum punishment for drinking and driving from two to four years in prison, with the possibility of seven years if death resulted from the event (18). No clear support could be obtained for any effect of this innovation upon casualties. In addition, in a study commissioned for this research project from the Swedish Institute for Public Opinion, less than one per cent of a random sample said they would be more inclined to risk driving after drinking were the penalty to be changed to merely the loss of a driver's license (22).

I am led to the speculation that the key to the success of the British law was the Government's success in convincing British drivers in 1967 that there was a significant risk of apprehension by the police for drivers who drank more than the permissible amount of alcohol. The Act was launched with a major publicity campaign, but the impression of a danger of apprehension was probably also bolstered by the prior public debate on the law, and by the continuing mention of the law occasioned by its vicissitudes in the courts during the first years of the Act. The fact that the effect of the legislation appears to have diminished seems to me to reflect the lesson of experience in Britain – that the impression of enforcement was not grounded in the reality of police activity. The risk of apprehension for a drinking driver in Britain is realistically quite minute, and this fact is gradually being learned by the public, who are adjusting their behavior in consequence.

The Scandinavian *per se* laws are the oldest in the world, and the public there has had several decades in which to become familiar with the objective risk of apprehension in these countries. The poll I commissioned reported that, of the drivers in the sample, 18.5 per cent had never been stopped by the police for any kind of control, and an additional 6.13 per cent had not been stopped within the past year. The famous roadblocks are in actuality quite rare – at present Stockholm has only two per month – and are predictable as to time and place. Even if stopped by a patrol, many alcohol-influenced drivers would fail to arouse police suspicion, without which no tests for alcohol can be given in any Scandinavian country. Most arrests in Scandinavia for drinking and driving appear in fact to occur as the result of accidents, when the public calls the police (12, 14).

Of course, understanding the British case in terms of learning does not explain the fact that the Scandinavian data show little or no evidence of deterrence even at the points of inception of their laws. It may well be that the Scandinavian governments were never able to produce a credible threat of apprehension in their legislation. Perhaps, as some Swedes argue, their drinking drivers are particularly difficult to deter. Perhaps other features of Scandinavian society – especially the puritanical attitudes towards alcohol and the controls over its distribution – may have preceded the law in deterring the drinking driver to the limits of the ability of social control measures.

I would like to note that the Scandinavian data series I have examined would today support very sensitive studies of changes in the drinking-and-driving laws. The severe fluctuations of early years have disappeared from the curves, in part because of the lack of catastrophic events like a world war and in part because of the maturation of these societies in terms of the use of the automobile. The statistical series have increased in sophistication, detail, and accuracy. They easily reveal, for instance, an impressive effect on casualties of the safety measures associated with the 1967 shift in Sweden from left- to right-hand driving. If and when such currently discussed changes as elimination of the automatic prison sentence are accomplished, it will be possible to evaluate them with confidence and to learn much more about the interesting question of the effect of law on behavior.

REFERENCES

1. Berglund, E. and Johansson, K., *Rattfylleristen*, Uppsala University, Beteendevetenskapliga Institutionsgruppen, Kriminalvärdsstyrelsen Rapport No. 8, 1974.
2. Bratholm, A. and Hauge, R., Reaksjonene mot promillekjørere, *Lov og Rett* 1974, p. 24.
3. Bjerver, K. B., Goldberg, L. and Linde, P., Blood Alcohol Levels in Hospitalized Victims of Traffic Accidents. In *Proceedings of the Second International Conference on Alcohol and Road Traffic*, 1955, p. 92.

4. Carr, B. R., Goldberg, H. and Farbar, C.M.L. *The Breathalyzer Legislation: An Inferential Evaluation*. Ministry of Transport, Ottawa, 1974.
5. Cosmo, C. J., The Swedish Legislation Regarding Traffic Sobriety Offences, *Blutalkohol,* 10, (1973).
6. Gardiner, J., *Traffic and the Police*. Harvard University Press, Cambridge, Mass., 1969.
7. Goldberg, L., Tolerance to Alcohol in Moderate and Heavy Drinkers and its Significance to Alcohol and Road Traffic. In *Proceedings of the First International Conference on Alcohol and Road Traffic*, 1951, p. 85.
8. Goldberg, L., Drunken Drivers in Sweden. In *Proceedings of the Second International Conference on Alcohol and Road Traffic*, 1955, p. 112.
9. Haddon, W., Jr., The Problem Drinker and Driving: Questions of Strategy in Countermeasure Choice and Development. In Filkins, L. D. and Geller, N. J. (Eds.), *Proceedings of a Conference on Community Response to Alcoholism and Highway Crashes*, Highway Research Institute, University of Michigan, Ann Arbor, 1970, p. 13.
10. Hansson, C., *Alkohol och läkmedel vid dödsolyckor i trafiken i södra Sverige*, manuscript distributed by the Swedish Forensic Medical Station (Statens rättsläkarstationen), Lund, 1972.
11. Havard, J.D.J., The Drinking Driver and the Law. A draft chapter prepared for Yedy Israel (Ed.) *Research Advances in Alcohol and Drug Problems*, Vol. 2, in press.
12. Kaltenborn, A. M., *Fyll, bil og fengsel*, Institute for the Sociology of Law, University of Oslo, mimeographed occasional paper, 1968.
13. Klette, H., Nagra resultat fran tre rattfyleriundersökningar jämförda med trafiknykterhetskommittens lagförslag. *Nordisk Tidsskrift for Kriminalvidenskab,* 52, p. 119 (1963).
14. Klette, H., *Om rattfyllerilagstiftningens verkningar*, Lic. thesis, Lund University, 1966.
15. Klette, H., *On the Functioning of the Swedish Legislation concerning Drunken Driving*, paper delivered at the International Sociological Association, Evian, France, 1966.
16. Lindell, I., Legal Problems of Alcohol and Traffic. Lecture at Istanbul, Turkey, September 12, 1956, published in pamphlet form.
17. Ross, H. L., Law, Science and Accidents: The British Road Safety Act of 1967, *Journal of Legal Studies,* 2, (1973).
18. Ross, H. L., The Scandinavian Myth, *Journal of Legal Studies*, forthcoming.
19. Selzer, M. I., *A Scandinavian Myth*? Privately circulated, no date.
20. Surell, V., *The Importance of General Prevention in the Combating of Drunken Driving.* Swedish Temperance Motorists' Association, mimeograph, no date.
21. Sveri, K. and Klette, H., In SOU 1970: 61, *Trafiknykterhetsbrott.*
22. Swedish Institute for Public Opinion (SIFO), *Alcohol Consumption and Driving*, mimeograph, 1974.
23. Swedish Parliamentary Commission of Inquiry: SOU 1969: 42, *Skattebrott.*
24. Swedish Parliamentary Commission of Inquiry of 1970: SOU 1970:61, *Trafiknykterhetsbrott.*
25. Swedish Parliamentary Commission of Inquiry of 1970: SOU 1970: 61, *Trafiknykterhetsbrott*, p. 116.
26. Swedish Temperance Motorists' Association (MHF), Official Opinion on SOU 1970:61, *Trafiknykterhetsbrott*, mimeograph, 1971.

The Canadian Breathalizer Legislation: An Inferential Evaluation

Brian R. Carr,[1,2] H. Goldberg and C.M.L. Farbar

The Criminal Law Amendment Act, popularly known as the Breathalizer Legislation, came into force on December 1, 1969. The new legislation gave police officers in Canada the power to demand on reasonable grounds, that a driver suspected of alcohol impairment take a breath test. The law made it an offence for a driver to have a blood alcohol content (BAC) over .08% or 80 mg/100 ml. It was still possible for a driver to be convicted of impaired driving at a lower BAC.

If the breath test was refused, the driver was considered guilty of a .08% infraction and was liable to the same penalties, namely, up to $1,000 in fines and/or 6 months in jail.

Changes in Legislation

The purpose of this paper is to evaluate the effect of the Breathalizer Legislation in reducing serious road accidents. Since alcohol is involved in about one-half of all fatal accidents in Canada, it is reasonable to look first at the fatal accident figures. In 1969 there were 4,549 reported fatal accidents, while in 1970, the first full year after the introduction of the new legislation, there were only 4,264, a drop of 6.3%. At the same time there are indications that there was an increase in road usage over this period. Motor vehicle registrations increased by 2.9% in 1970 compared to the previous year; gasoline sales were up 5.9% on the same basis. However, the United States experienced a drop in fatal accidents of 2.1% at the same time, without the benefit of similar legislation. It might be reasonable to assume, therefore, that some of the fatal accident reduction in Canada may have been due to other factors, such as the increased penetration of motor vehicle safety standards into the vehicle population. Other than the safety standards, there were no national road safety initiatives introduced in Canada in 1970.

Since the new legislation was expected to be effective through a deterrent effect on impaired driving, it could only plausibly have had a positive effect if people were aware of its introduction and its contents in some detail. In order to develop this awareness, the Federal Government produced a series of television spots that were

---

[1] Road Safety Branch, Ministry of Transport, Ottawa, Canada.

[2] The material for this paper has been extracted from a Ministry of Transport report with the same title that is available through Information Canada (4).

aired in public service time to inform the public of the provisions of the new legislation. There was also much coverage in the press and other media reflecting the high public visibility of the Breathalizer Legislation.

In order to determine the extent of the increase in public knowledge, the Ministry of Transport contracted a two-wave ('before and after') telephone survey of 1,000 drivers across Canada in each wave. The results of this survey are reported elsewhere (6), but the primary results are described in Figure 1. Knowledge of all principal provisions of the legislation increased in the 'after period'.

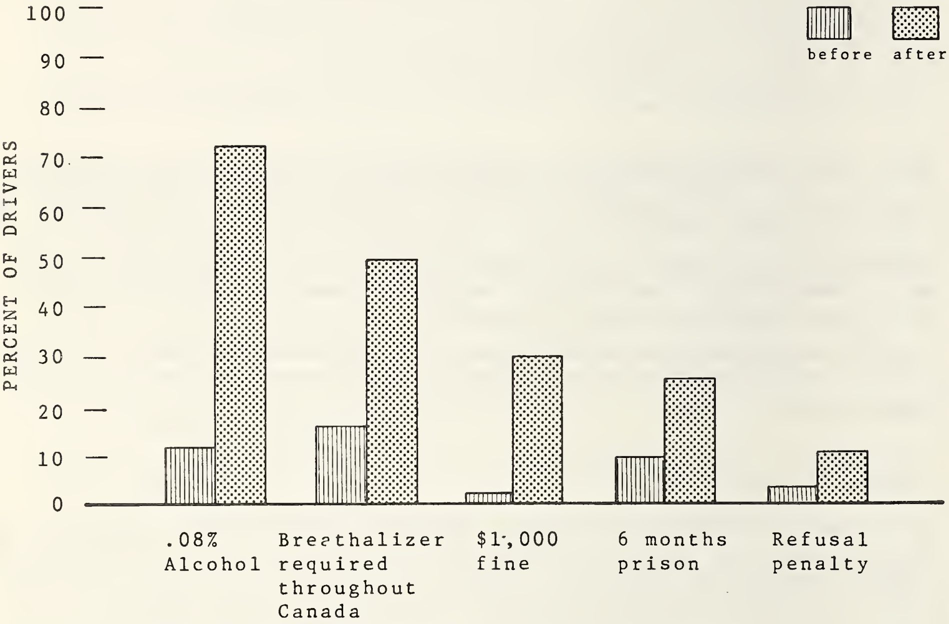


Figure 1 *Levels of knowledge of 5 specific provisions of the new legislation.*

Tables I and II show the trend in fatal accidents around the period of interest (7). It is clear that Canadian fatal accident totals stayed fairly constant with only minor fluctuations through the last half of the sixties. The drop in 1970 was greater than any previous year. Since 1970, though, there have been major increases; both in 1971 and 1972. This trend shows some evidence of a small, short-term effect of the Breathalizer Legislation.

The next question to answer is how widespread was the decrease in fatal accidents in 1970 across Canada? After all, a national countermeasure should produce national results.

In the West, all the Prairie provinces showed a decrease in fatal accidents in 1970 of between 10% and 15%. British Columbia stayed pretty well level. Only Alberta's decrease held on through 1971. Both Quebec and Ontario showed some decrease in fatal accidents in 1970. However, 1971 accidents exceeded the 1969 levels. Three of the four Maritime provinces showed decreased in 1970, while New Brunswick remained roughly constant. Maritime fatal accidents rose in 1971 but not quite to 1969 levels. Thus the decrease in fatal accidents post-Breathalizer was felt across the country, followed by a general rise in 1971 (Tables I & II).

TABLE I *Provincial Fatal Accidents*

Province	1969	1970	1971
Newfoundland	74	61	77
Prince Edward Island	38	28	27
Nova Scotia	210	182	191
New Brunswick	181	183	176
Quebec	1,442	1,411	1,463
Ontario	1,410	1,300	1,498
Manitoba	152	132	150
Saskatchewan	177	159	174
Alberta	379	320	322
British Columbia	467	471	538
Yukon, Northwest Territories	19	17	17
Total	4,549	4,264	4,633

TABLE II *Total Fatal Accidents in Canada, 1966-1972*

Accidents	1966	1967	1968	1969	1970	1971	1972
Actual	4446	4535	4422	4549	4264	4670	5233
Index[a]	100	102	99	102	96	105	118

[a] The index is calculated by taking 1966 as a base.

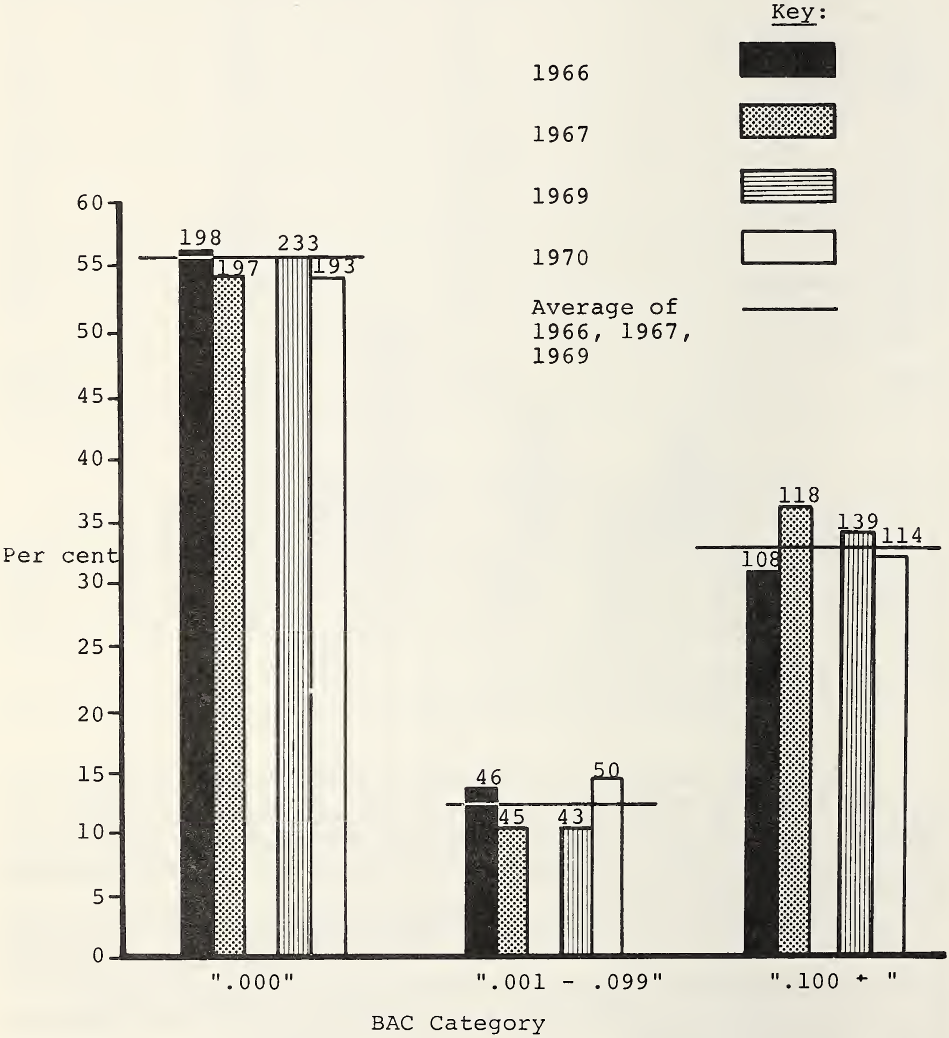
A more direct indication of the effectiveness of the Breathalizer Legislation can be found by looking at fatal accidents as a function of time (8). Presumably, the legislation if effective, would have had more effect during those times when drinking was more prevalent, namely at night (taken as 10 p.m. to 4 a.m.) and weekends (taken as Friday, Saturday and Sunday).

This "drinking times" analysis was conducted using data from all provinces except British Columbia, New Brunswick, and Quebec. Since the first two of these provinces experienced no decline in fatal accidents in 1970, they were removed from the analysis to avoid any possible dilution of the (presumed) effect of the legislation. Quebec data were not available in sufficient detail to be included.

In 1969, night-time fatal accidents for the seven provinces comprised 29% of all fatal accidents. In 1970 this percentage dropped to 27%. In 1969, weekend fatal accidents accounted for 58% of the total, falling to 56% the following year.

Data providing the most direct insight into the possible effect of the Breathalizer Legislation are available from the provincial coroners of Ontario, Alberta and New Brunswick (2, 3). In these provinces, local coroners are required to test the blood of all deceased drivers for alcohol. It was reasoned that if the Breathalizer Legislation were effective, then impaired drivers should account for a smaller proportion of total driving and hence of total fatal accidents. As a result, fewer fatally injured drivers should have impairing quantities of alcohol in their blood.

Figure 2 shows the BAC for drivers killed in multi-vehicle accidents in 1966 through 1970 (1968 data are not available). Drivers with a BAC of .10% and above comprise a proportion of the decreased drivers only marginally below the average of previous years.



Figre 2 *BAC for drivers killed in multi-vehicle accidents, 1966-1970. Each annual total is equal to 100%. The data for 1968 are not available.*

Single vehicle accidents have a much greater alcohol involvement as is evidenced by Figure 3. Once again the percentage of fatally injured drivers with impairing levels of alcohol in their systems in 1970 is virtually the same as the average in previous years.

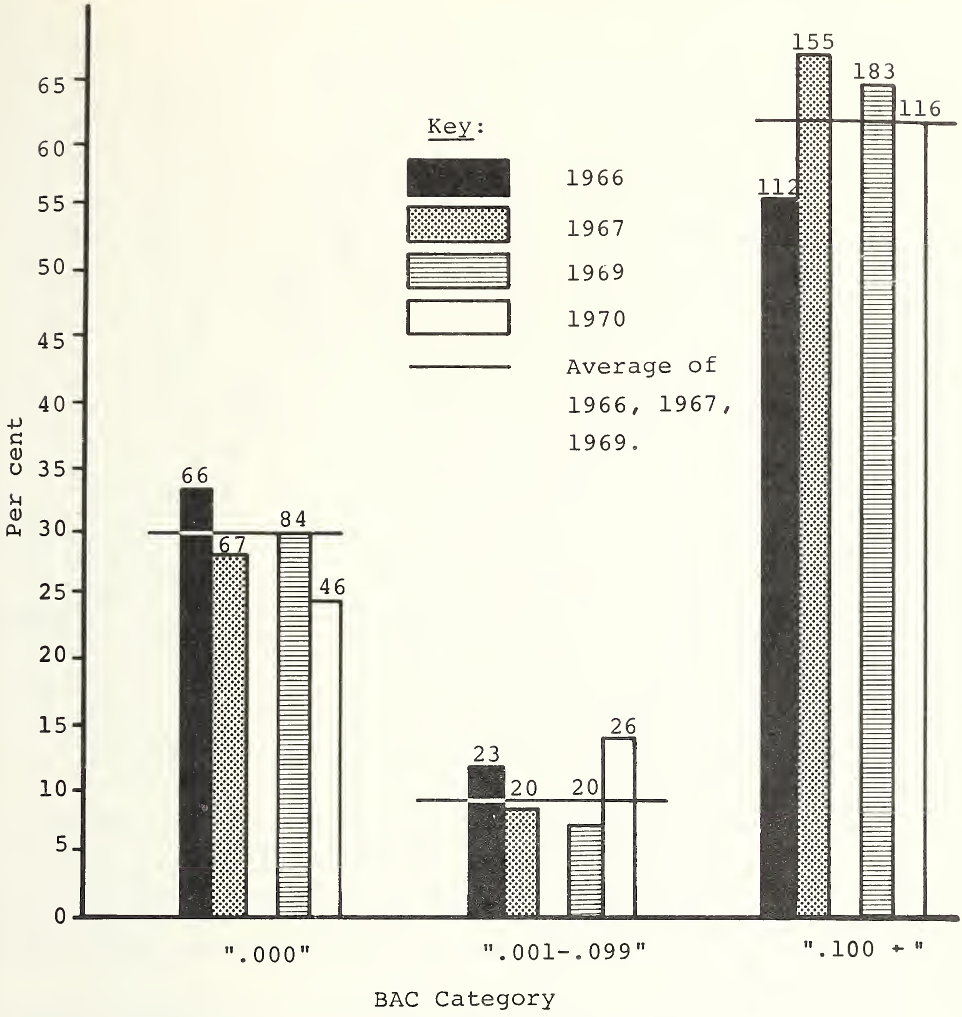


Figure 3 *BAC for drivers killed in single-vehicle accidents, 1966-1970. Each annual total is equal to 100%. The data for 1968 are not available.*

Changes in Police Activity

While there is not very much specific evidence of the effectiveness of the legislation, there is considerable evidence of changes in police activities. In Ottawa for example, 50% more drivers were required to take a breath test in 1970, compared to the previous year when the breath test had been voluntary. In both years, however, the average BAC of tested drivers was very high, namely .21% and .19% in 1969 and 1970 respectively. The distribution of BAC in both years is illustrated in Figure 4. The distributions are very similar, except in that segment between .08% and .20%. A reasonable interpretation of this difference is that in 1970 the police were more likely to charge a person suspected with impaired driving, since in this year results of the breath test alone were sufficient to prove impairment. In 1969, breath test results had to be corroborated by physically observed symptoms to obtain a conviction. Generally speaking, fewer such symptoms are present at lower levels of impairment.

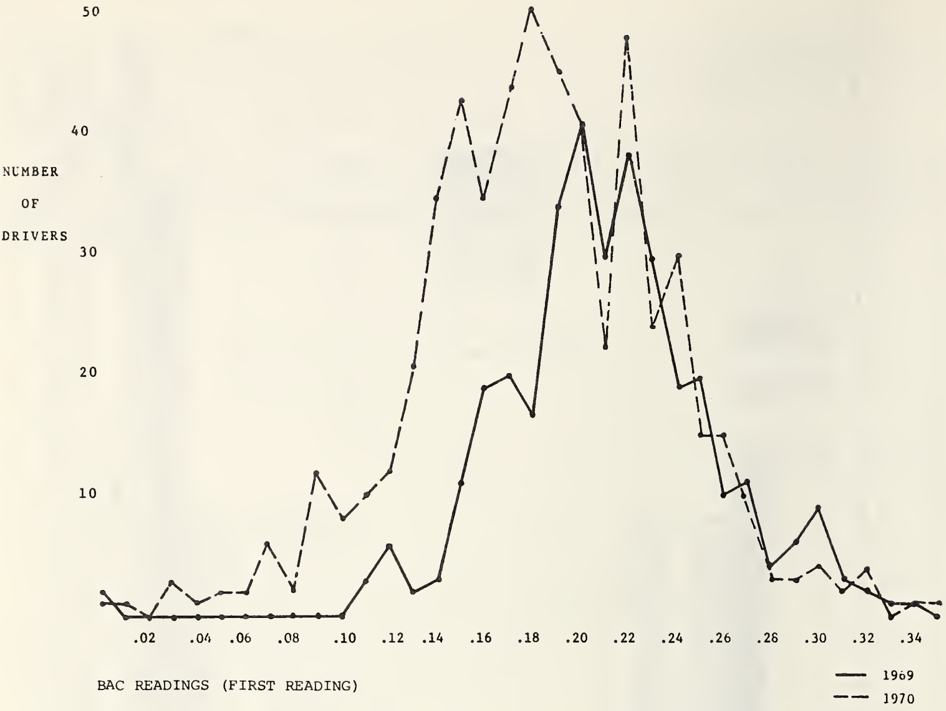


Figure 4 *Alcohol influence reports – Distribution of BAC readings for 1969 and 1970.*

Impaired driving charges increased substantially across Canada in 1970 (9). A sample of charge data is provided in Figure 5.

The introduction of the new legislation did not appear to affect the sale of alcoholic beverages (5). Table III indicates that a slight trend towards home consumption of beer (that is, packaged sales) is noticeable throughout the late sixties and early seventies.

The evidence to date demonstrates convincingly that the Breathalizer Legislation did not have a large or sustained effect in Canada. However it is not known why this was the case nor what changes could be made to create the desired reduction in alcohol-involved serious accidents. Some insight can be provided on these important questions by comparing the Canadian results with the effect of the Road Safety Act introduced in the United Kingdom in 1967 (1). Table IV shows the changes in the numbers of victims killed and injured in the two nations in a comparable format.

Comparison of the Effects of Legislation in Canada and the U.K.

It is clear that a substantial reduction in victims occurred in the United Kingdom, lasting for three years. On the other hand, Canada experienced a one-year reduction with no positive effects demonstrable after this time. Table V provides comparable figures on the BACs of fatally injured drivers. In the U.K., the proportion of drivers exceeding .08% fell from 25% to 15% immediately following the introduction of the Road Safety Act. It was not until four years after the introduction of the legislation that this reduction had completely worn off.

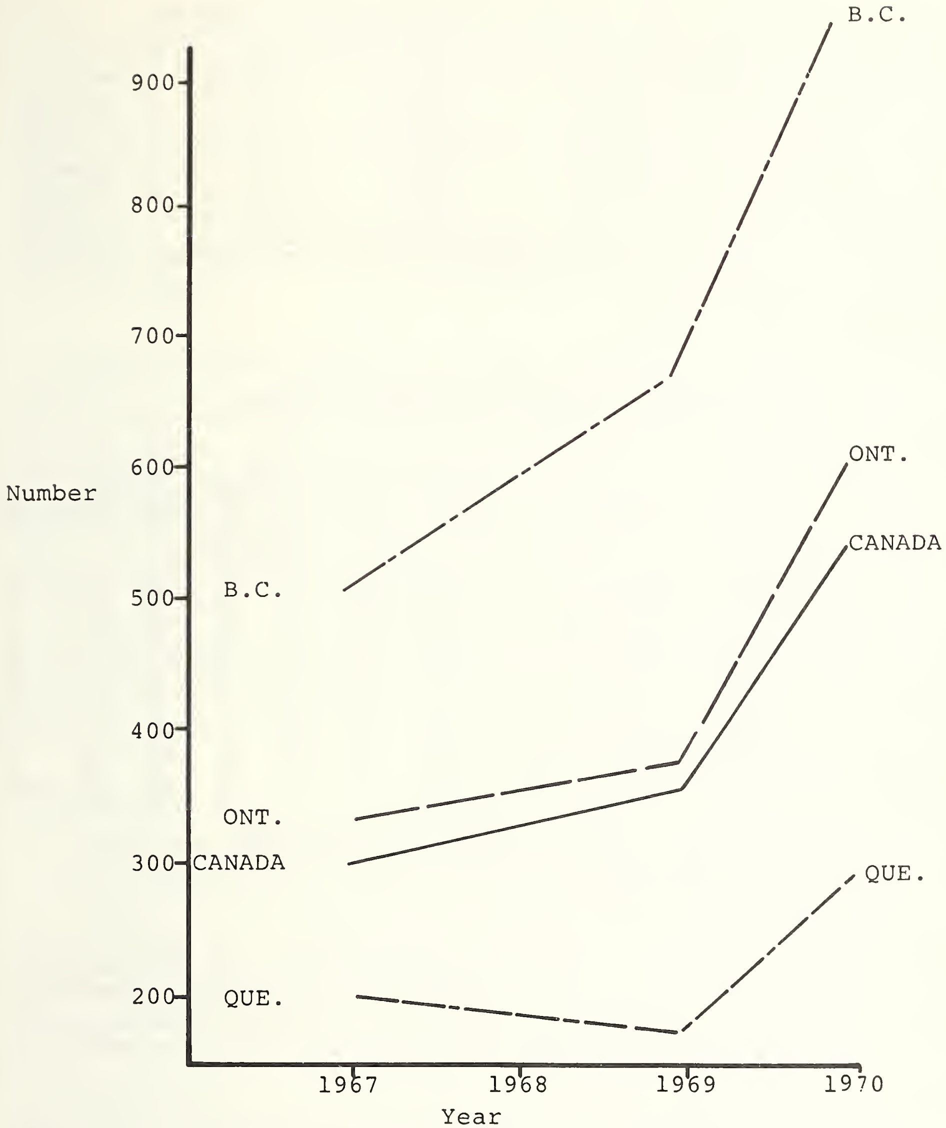


Figure 5 *Drinking-driving charges per 100,000 population 16 years of age or older.*

TABLE III *Canada Beer Sales Index (1967 = 100)*

Type of beer	1967	1968	1969	1970	1971
Draught	100	96.6	101.2	99.4	101.3
Packaged	100	101.5	108.4	114.9	124.8
Total	100	100.6	106.9	111.7	119.9

TABLE IV *Comparison of Road Casualty Trends: Great Britain vs Canada*

Country		BY-1	BY	BY+1	BY+2	BY+3
Great Britain		Oct. 1965-Sept. 1966	Oct. 1966-Sept. 1967	Oct. 1967-Sept. 1968	Oct. 1968-Sept. 1969	Oct. 1969-Sept. 1970
	Killed	7,771	7,898	6,746 (-14.5)[a]	7,084 (-10.3)	7,446 (-5.7)
	Injured	382,842	378,554	339,247 (-10.3)	341,858 (- 9.7)	352,118 (-6.9)
Canada		Jan. 1968-Dec. 1968	Jan. 1969-Dec. 1969	Jan. 1970-Dec. 1970	Jan. 1971-Dec. 1971	Jan. 1972-Dec. 1972
	Killed	5,318	5,425	5,080 (-6.4)	5,573 (+2.7)	6,221 (+14.7)
	Injured	173,901	180,829	178,501 (-1.3)	192,501 (+6.5)	215,705 (+19.3)

[a] Figures in parentheses denote percentage change from the Breathalizer Year (BY).

TABLE V *Comparison of Persons Killed: Great Britain vs Canada, Data Supplied by Coroners*

Country	Time period	Sample Size	% with BAC exceeding					
			9	50 mg/100/ml	80	100	150	200
Great[a] Britain	Dec. 1966-Sept. 1967 (By)[b]	544	37	29	25	22	13	6
	Dec. 1967-Sept. 1968 (By + 1)	389	26	17	15	14	10	4
	Dec. 1968-Sept. 1969 (By + 2)	454	29	22	19	17	11	5
	Dec. 1969-Sept. 1970 (By + 3)	459	29	23	19	16	12	6
Canada[c]	Jan. 1969-Dec. 1969 (By)[b]	702	55	N/A	46	43	N/A	N/A
	Jan. 1970-Dec. 1970 (By + 1)	609	58	51	46	42	30	18
	Jan. 1971-Dec. 1971 (By + 2)	690	53	47	44	40	27	15

[a] England and Wales only, within 12 hours of accident-drivers and passengers.
[b] By Denotes Breathalizer Year.
[c] Ontario, Alberta, New Brunswick only.
N/A = Not Available.

Table VI illustrates the surprising fact that many more drinking-driving prosecutions took place in Canada despite the fact that the Population of the United Kingdom is more than double that of Canada. So it is clear that the absolute level of police enforcement is not directly responsible for the comparative effectiveness of the United Kingdom legislation.

A comparison of the contents of the two pieces of legislation shows a number of possibly significant differences. In the United Kingdom, a police officer has the discretionary power to require a breath test if he suspects a driver has been drinking, involved in a traffic accident, or has committed a moving traffic violation. In Canada, a police officer can demand a breath test only if he has reasonable grounds to suspect that the driver is impaired (not just "had been drinking"). The police officer in the U.K. can also require a qualitative breath test at the roadside. This test can determine if the driver is over the legal limit with some reasonable level of accuracy. If the test is positive, a quantitative test is administered at the police station. In Canada, the use of such a screening test can not be required by a police officer.

These differences in discretionary police powers may well be significant in terms of the perception of the risk of enforcement experienced by potential impaired drivers.

TABLE VI *Comparison of Drinking-Driving Law Enforcement Levels Great Britain vs Canada*

Total Number of Prosecutions	BY[a] (Jan-Dec)	BY+1 (Jan-Dec)	BY+2 (Jan-Dec)
England and Wales	N/A	17,995	23,926
Canada	48,046	78,094	94,618

[a]BY denotes Breathalizer Year: Canada-1969, Great Britain-1967.
N/A = Not Available

Another difference concerns the public information campaigns in the two countries. The driving public in the United Kingdom were unfamiliar with chemical breath testing devices before the introduction of the Road Safety Act in 1967. The public information campaign associated with the introduction of this Act was designed (with apparent success) to create the public impression that serious consequences would very likely befall an impaired driver. In Canada, the campaign was designed more to provide information than to change attitudes. The Canadian public was also already familiar with the Breathalyzer, as it had been used on a voluntary basis before the introduction of the new legislation.

It would appear then, that the shock value of the introduction of the legislation in the United Kingdom was greater than that in Canada. However, even this greater effect did die out after three years.

REFERENCES

1. Beaumont, K., and Newby, R. F., Traffic Law and Road Safety Research in the United Kingdom – British Countermeasures, *National Road Safety Symposium,* Symposium Preprint, Combined Session 2, Canberra, Australia, 14 - 16 March, 1972.
2. Campbell, E. O'F., Alcohol Involvement in Fatal Motor Vehicle Accidents, *Modern Medicine*, 24, No. 4, 35 - 42, (1969).
3. Campbell, E. O'F., Alcohol Involvement in Fatal Motor Vehicle Accidents 1966 – 1969, *Modern Medicine*, 26, No. 7, 7 - 10, (1971).
4. Carr, B. R., Goldberg, H., and Farbar, C.M.L., *The Breathalizer Legislation: An Inferential Evaluation*, Transport Canada, Ottawa, Ontario, Canada, 1974.
5. Cumulative Review, *Sales Bulletin*, Brewers Association of Canada, Ottawa, Ontario, December 1969 – 71.
6. Kates, Peat, Marwick and Company, *Awareness of the Breathalizer Legislation*, prepared for the Road and Motor Vehicle Traffic Safety Branch of the Ministry of Transport, June 1970.
7. *Motor Vehicle Traffic Accidents 1970*, Statistics Canada, annual, catalogue number 53-206, 1971.
8. *Motor Vehicle Traffic Accidents 1970*, Statistics Canada, quarterly, catalogue number 53-001, 1971.
9. *Traffic Enforcement Statistics 1970*, Statistics Canada, annual, catalogue number 85-206, 1972.

The Epidemiology of Traffic Accidents and the Effect of the 1969 Breathalyser Law in Canada

Larry W. Chambers,[1] Robin S. Roberts and Cameron C. Voelker.

The Canadian public is becoming 'hardened' to highway deaths and injuries ubiquitous in our society. In 1971, 5616 deaths were attributed to this cause (7), representing the fourth most common cause of death, following heart disease, cancer and cerebrovascular disease. Unlike the first three causes, motor vehicle traffic accidents seem targeted at Canadians with the greatest number of years ahead of them. That is, traffic deaths and injuries occur most frequently in younger age groups (7). Many Canadians felt our neighbours to the south demonstrated a 'hardness' towards death and injuries of their younger people in a remote Far Eastern War in the 1960s.[2] The Canadian public seems to be demonstrating a similar insensitivity to proportionally even greater numbers of deaths and injuries occurring on Canadian highways (6,7,8).

Attempts to reduce the carnage caused by traffic accidents have concentrated on the legislative approach through the compulsory addition of certain safety features in automobiles (for example, seat belts), the introduction of more stringent penalties for driving offences, and, in particular, amendments to Canada's Criminal Code regarding impaired driving. The basic Criminal Code Sections related to impaired driving are Section 234, which prohibits "Driving while ability to drive is impaired", Section 235, "Failure or refusal to provide sample of breath where (there exists a) reasonable belief of commission of offence under Section 234", and Section 236, "Driving with more than 80 mgs of alcohol (per 100 millilitres) in blood". Other sections clarify technicalities and terminological intent of these three. Section 236 only came into effect in 1969 (1). This amendment gave the police power to arrest a driver on the basis of a positive breathalyser test, or for refusal to submit to such a test. The list of measures adopted to curb motor vehicle accidents will grow over time as will the need to assess their effectiveness.

This paper describes an epidemiologic approach to evaluating accident prevention programmes and uses the breathalyser amendment, Section 236, as a model application. Its prime objective is not to state categorically the level of success or failure of the breathalyser in reducing traffic accidents for too short a period has elapsed since its introduction to permit an unequivocal answer. Rather, the purpose of this paper is to suggest an appropriate epidemiologic evaluation, in contrast to more traditional methods, that permits an on-going assessment of the effectiveness of this or other innovations in traffic safety.

---

[1] Division of Community Medicine, Faculty of Medicine, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.

[2] 1968 was the worst year for the United States in the Vietnamese War as 14,592 Americans were killed that year in Vietnam. This represents a death rate of approximately 7 per 100,000 (the 1968 United States population was 200,619,000). In 1971, there were 5616 deaths from traffic accidents in Canada representing a death rate of approximately 26 per 100,000 (the 1971 Canadian population was 21,568,310).

EPIDEMIOLOGIC EVALUATION OF TRAFFIC ACCIDENTS

Indices used to assess the effect of traffic accident prevention programmes must be designed to gage accurately the change between periods before and after the introduction of a programme. The relevence of before/after comparisons is dependent upon the appropriateness of the health outcomes chosen and measured by such indices.

In the present analysis, the classic epidemiologic measures of disease frequency, incidence rate, mortality (or death) rate, and case fatality rate, are used as indices to assess a traffic safety innovation's total impact on the health of a community. These rates are defined as follows: Incidence Rate is the total number of deaths and injuries from motor vehicle traffic accidents over a specific period of time divided by the population of the community at risk during the same period of time; Mortality Rate is the total number of deaths from motor vehicle traffic accidents over a specific period of time divided by the population of the community at risk during the same period of time; and, Case Fatality Rate is equal to the total number of deaths from motor vehicle traffic accidents over a specific period of time divided by the total number of injuries and deaths from motor vehicle traffic accidents during that same period of time (Figure 1) (2).

$$\text{INCIDENCE RATE} = \frac{\text{TOTAL NUMBER OF DEATHS } \underline{\text{AND}} \text{ INJURIES FROM MOTOR VEHICLE TRAFFIC ACCIDENTS OVER A SPECIFIC PERIOD OF TIME}}{\text{THE POPULATION OF THE COMMUNITY AT RISK DURING THE SAME PERIOD OF TIME}}$$

$$\text{MORTALITY RATE} = \frac{\text{TOTAL NUMBER OF DEATHS FROM MOTOR VEHICLE TRAFFIC ACCIDENTS OVER A SPECIFIC PERIOD OF TIME}}{\text{THE POPULATION OF THE COMMUNITY AT RISK DURING THE SAME PERIOD OF TIME}}$$

$$\text{CASE-FATALITY RATE} = \frac{\text{TOTAL NUMBER OF DEATHS FROM MOTOR VEHICLE TRAFFIC ACCIDENTS OVER A SPECIFIC PERIOD OF TIME}}{\text{TOTAL NUMBER OF INJURIES AND DEATHS FROM MOTOR VEHICLE TRAFFIC ACCIDENTS DURING THAT SAME PERIOD OF TIME}}$$

Figure 1 *Definitions of incidence, mortality and case-fatality rates.*

These epidemiologic measures are proposed in preference to traditionally adopted "casualty rates" (3, 5) for a number of reasons. Firstly, an index such as "casualties per 100 million vehicle miles" has an inappropriate denominator to correct for changes in the level of population risk when 22 to 25 per cent of fatalities occur in pedestrians. Secondly, such an index may not describe the true impact on the population's health of a traffic safety innovation such as the breathalyser since the index would remain unchanged if fatalities were reduced only as a result of deterring people from driving.

Finally, epidemiologic measures have inherent advantages in describing the mode of action of an effective traffic safety innovation by being able to separate preventive effects (that is, a reduction in incidence rate) from a measure's ability to reduce the severity of resulting injury (that is, a reduced case fatality rate) and further that mortality rate is the most appropriate index of road fatality.

These three components of the effect are clearly *not* independent since the three measures share the relationship: Mortality rate = incidence rate X case fatality rate.[3] From this relationship it is apparent that mortality rate will be affected by changes in either or both the incidence and the case fatality rate. The separation of these two potential effects leads to a more meaningful explanation of any change in mortality resulting from an implemented programme. Such indices could thus better distinguish between the effects of programmes having different primary foci – for example, accident prevention programmes, improved automobile safety features and the long-term improvement of patient care techniques.

Motor vehicle traffic accident data were obtained from Statistics Canada's "Quarterly Reports of Motor Vehicle Traffic Accidents" (9) for the years 1963 to 1971. The period between 1963 and 1969 seemed sufficient time to establish trends of motor vehicle traffic accidents prior to the introduction of the breathalyser law. Data in these quarterly reports are based on police records of personal injury accidents. Minor accidents or accidents where those injured left the scene of the accident may not have been reported. However, injury reported by police serves as a useful and fairly constant definition for the occurrences of the 'disease event'. Deaths and injuries were abstracted for three-month periods (quarter year) by hour of the day of the accident in order to attempt to describe as fully as possible patterns of motor vehicle traffic accidents. For example, if the breathalyser law was effective, one would expect only those hourly rates to change which coincided with times when the consumption of alcoholic beverages was high. Such a "gradient of effect" with consumption habits would be weighty evidence of the breathalyser's efficacy.

As mentioned earlier, any initial conclusions made from this analysis must be weighed against the limitations of the presently available data. Canada's breathalyser law was in universal effect for all of the first quarter of 1970. Because of routine delays in reporting from some provinces, Statistics Canada has only published data on motor vehicle traffic accidents up to the first quarter of 1971, and at the time of this writing it is not clear when more data will be forthcoming. Also, these data are limited because provinces tend to be unable to agree on a common format for reporting motor vehicle traffic accidents and Statistics Canada data are always limited to the lowest common denominator of the breakdown of data provided by each province. For example, some provinces (Manitoba and Quebec) did not report some quarters and others such as Ontario, reported traffic accident data in much more detail than did other provinces.

---

[3] This relationship holds exactly if the traffic accident deaths are attributed to the time period in which the accident occurred rather than the time period in which the death occurred (the current reporting practice). Since almost all traffic accident fatalities occur within the first week after the accident the effect of a time lag on quarterly mortality rates is negligible and thus the relationship is appropriate.

METHODS

Population estimates for the years 1963 to 1971 were required in order to calculate motor vehicle traffic accident mortality and incidence rates for those years. These yearly population estimates were obtained from Statistics Canada (10). Quarterly estimates were then calculated. When provinces had failed for certain quarter years to report to Statistics Canada their motor vehicle traffic accident data, corrections were made so that a true population at risk was established.

Incidence, case-fatality and mortality rates for each quarter were computed for the total day and also for four periods during the day: 6 a.m. to 12 noon; 12 noon to 6 p.m.; 6 p.m. to 12 midnight; and 12 midnight to 6 a.m. The number of people killed or injured were not reported by hour of day, necessitating the use of accidents involving death or injury as a surrogate in an attempt to relate the effect of the breathalyser on alcohol consumption patterns. Although this is a less satisfactory approach it should exhibit similar trends to the desired data. The 'total day' incidence, case-fatality and mortality rates were calculated using the appropriate data and were plotted over time.

As any programme of accident prevention may have effects on either or both the incidence and the case fatality rates and since these, together, affect mortality rate, separate models were constructed for incidence and case fatality. Two regression models were fitted to the incidence and case fatality data explaining the variation in terms of (a) a mean rate, (b) seasonal effects, (c) linear time trend, and (d) breathalyser effect (Appendix A). A regression model was fitted to the total rates and to the rates for the four periods during the day.

The product of the predicted values for incidence and case-fatality was used as an estimate of mortality in each quarter. This method was chosen after observing linear trends in both incidence and case-fatality rates but a non-linear trend in mortality rate (Figure 2). It was reasoned that this is to be expected because mortality rate is equal to the product of the incidence and case-fatality rates. Further, since each of these rates exhibit apparent linear trends with time, their product will be quadratic with time. Since only two of the three rates could be independently modelled, the variation in the third should be explained by the appropriate combination of the predicted values of the other two.

Finally, the mortality in the post breathalyser period was examined in the five quarters (three-month periods) after the introduction of the breathalyser law. Estimates were calculated of the mortality rate that would have been expected if the breathalyser had *not* been introduced. This was achieved by extrapolating the mortality estimates beyond the last quarter of 1969 but with the breathalyser effect removed. The difference between these predictions and the mortality estimates including the breathalyser effect was calculated. The differences between the observed mortality rate and the mortality estimates without the breathalyser were then summed over the last five quarters. This latter step provided an estimate of the number of lives saved by the breathalyser law, during the fifteen months after its introduction.

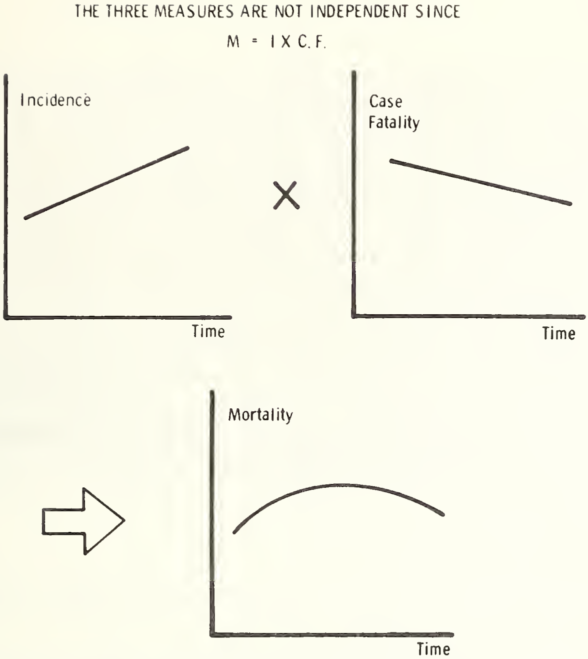


Figure 2 *Relationship between incidence, case fatality and mortality rates.*

RESULTS

Figure 3 shows the plots of 'total day' incidence, 'total day' case-fatality and 'total day' mortality. It was apparent from these graphs that the variation in all three measures was highly seasonal and thus a seasonal effect was a necessary component of the model. The incidence rate of injury from traffic accidents had been increasing fairly steadily over the time span of the data, whereas case-fatality rates appear to change at about the end of 1965. As a result, it seemed appropriate to model the longer time trends in these two rates with a linear trend based on the post-1966 data only. Inspection of the trend in the mortality rate over time supports a possible non-linear relationship.

The detailed results of the regression analysis are contained in Appendix A. The linear models provide good predictions of incidence and case-fatality both for the total rates, and for the rates broken down by the time period. For the model of total incidence rate, the breathalyser's introduction corresponds to a significant drop in incidence rate of 9.2 per 100,000 per quarter. The individual time period models show that this reduction is achieved mainly during the 6 p.m. to 12 midnight and 12 midnight to 6 a.m. periods, those times during which most alcohol is consumed. The model of total case-fatality rate also shows a reduction of 0.11 per cent after the breathalyser's introduction, although this effect is not quite statistically significant ($p \doteq 0.10$ single tailed test). The reduction appears to be mainly achieved in the afternoon and evening periods.

The effects of the breathalyser law on mortality are illustrated in Figure 4 in which the actual and predicted mortality rates are displayed. The overall fit is good,

DISCUSSION

Measurement of the breathalyser's impact on traffic accidents should be, in some ways, easier to demonstrate than when measuring the impact of other traffic safety innovations for two reasons: (a) the breathalyser law is unique as a preventive measure in that it came into effect at a specific point in time on the day the Bill was enacted; and, (b) the breathalyser law was applied universally through the Criminal Code of Canada, to all Canadian drivers. The introduction of seat belts and vehicle safety corresponding to a 95.6 per cent explained variation. In the last five quarters of the graph in Figure 4, we have added the mortality rate that would have been expected if the breathalyser had *not* been introduced (the dotted line). The difference between these predictions and the model's predictions including the breathalyser effect represents an average reduction of 0.46 deaths per 100,000 population per quarter. The sum of the differences between the observed mortality rate and the model's predictions without the breathalyser for the last five quarters represents a statistically significant reduction of 8.2 per cent or 487 deaths for Canada as a whole.

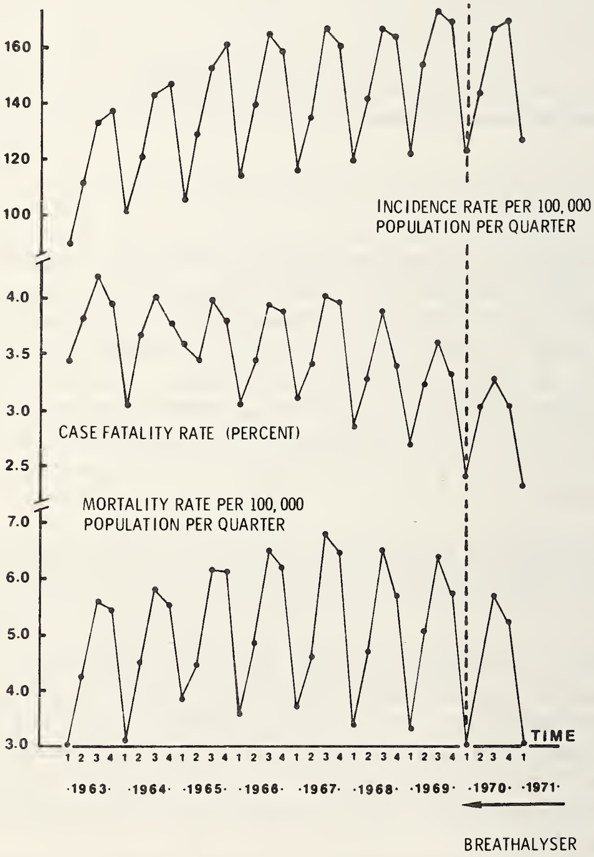


Figure 3 *Incidence, case-fatality and mortality rates for motor vehicle traffic accidents in Canada from 1963 to 1971.*

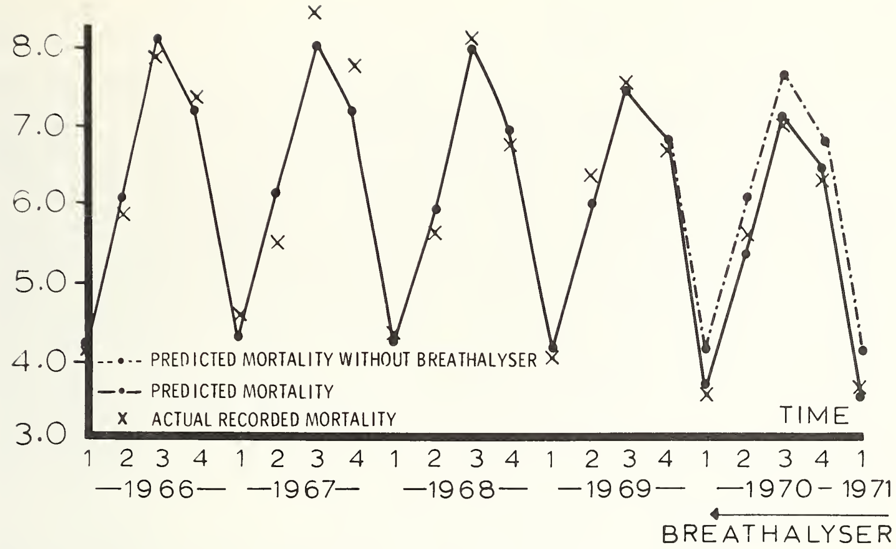


Figure 4 *Predicted and observed mortality rate for Canada from 1966 to 1971.*

features may well have affected the statistics although these factors were not applied universally nor were they introduced at a single point in time. Their gradual influence spans both the period before and after the breathalyser amendment and therefore may be contributing to the longer term movements in incidence, case-fatality and mortality. It is therefore unlikely that they can fully explain decreases in the post-breathalyser period revealed by the above analysis.

The classical epidemiologic measures of disease frequency applied to deaths and injuries from traffic accidents add a new dimension to the description of the phenomena. Our analysis has revealed that both the rate of injury (incidence) and the relative severity of injury (case-fatality) have strong seasonal fluctuations, the patterns of which are repeated over time with remarkable constancy. In addition, the long term trend of incidence is to increase and of case-fatality to decrease. Thus, while likelihood of injury from a traffic accident is increasing for the population at large, injuries sustained are becoming less severe, presumably reflecting the steady improvement in automobile safety features and road designs. These two longer term trends have conflicting effects on the mortality rate which, while arising steadily in the early part of the decade, appears to have levelled out by 1966. This is reflected in the model of mortality rate which predicts a slight downward movement in rate during the period immediately prior to the introduction of the breathalyser law.

The effectiveness of traffic safety measures based on changes in legislation is dependent on the enforcement of the new legislation. One could say that the initial effect of the breathalyser law has waned in Britain due to the fact that the total number of breathalyser readings taken in Britain averages out to only one per policeman per year (4). On the other hand, some have argued that the most one can expect is a substantial initial reduction in traffic accidents from breathalyser legislation. If this is so, then one logical next step that government could take after its first breathalyser law would be to decrease the milligram per 100 millitres level from the originally set level. For example, the legal blood alcohol level of 80 mg/100 ml could be lowered to

SUMMARY AND CONCLUSIONS

Classic epidemiologic indices have been applied to deaths and injuries from traffic accidents before and after the introduction of Canada's breathalyser law. The disease frequency measures incidence, case-fatality, and mortality focus on the breathalyser's health impact in relation to all the people at risk in a community over a specific period of time. This particular feature of these indices permits an ongoing community health assessment of the effect of the breathalyser law or other innovations in traffic safety.

A major hypothesis of this analysis has been that any programme of accident prevention may have effects on either or both the incidence and case-fatality rates and that these, together, affect mortality rate. The findings here have suggested that the introduction of the breathalyser law corresponded to reductions in *both* the incidence of injury (the greater reductions in incidence occurred during the "heavy drinking" periods of 6 p.m. to 12 midnight and 12 midnight to 6 a.m.) and the case-fatality rate, producing a magnified downward movement in mortality rate. The indicated magnitude of this effect represented a reduction of 487 deaths in Canada as a whole during the first five months in which the law was in effect.

As mentioned above, the prime objective of this paper has not been to state categorically the level of success or failure of the breathalyser in reducing traffic accidents. Rather, the purpose of this preliminary analysis has been to demonstrate the use of an appropriate epidemiologic evaluation that permits an on-going assessment of the breathalyser (or other innovations in traffic safety). All observations have been made taking into account that a short period has elapsed since its introduction. These findings in Canada may represent the initial "shock" effect of the law which appears to have occurred in Britain. And, like the British experience, the magnitude of the initial effect may taper out over time. Future evaluation of the Canadian experience will not be possible until the data become available.

APPENDIX A.

LINEAR REGRESSION MODELS

The linear regression models of incidence and case fatality rate were similar. For illustrative purposes, the incidence model is described below;

The model was of the form,

$$Y_{jk} = M + j.T + S_k + X.B.$$

Where

Y_{jk} = Incidence rate in the jth year and the kth quarter

M = Mean incidence rate (year zero)

T = Linear trend effect with year j

S_k = Seasonal effect for quarter k

X = A dummy variable given the value of zero for pre-breathalyser years and unity for post-breathalyser years

B = The breathalyser effect

Also, j = 1, 2 . . . . . 6 (for years 1966 - 1971)

k = 1, 2, 3, 4 (for each quarter)

$$\sum_{k=1}^{4} S_k = 0$$

60 mg/100 ml. Perhaps such an amendment to the original breathalyser law would elicit a response to traffic safety in a country seemingly otherwise insensitive to less universally applied preventive measures.

The above constraint on the sum of the quarterly effects prevented over parameterization. As a consequence, only three seasonal effects were estimated, the fourth being calculated as the negative sum of these three estimates.

The Table below gives the coefficients associated with each of the effects in the model, the level of statistical significance of the coefficient, and the percentage of variation explained by the model. As an example of the interpretation of these figures consider the upper part of the first column in the Table representing the model for total incidence rate. The overall mean incidence of injury from traffic accidents corrected to the year 1968, was 226.12 per 100,000 population per quarter. Over the span of the data, the incidence rate has been increasing significantly by 4.31 deaths and injuries per 100,000 per year on average. Incidence in the first two quarters of any year under observation is significantly lower than the overall yearly average (by 48.65 and 8.86 respectively) whereas the rate in the last two quarters is significantly higher (by 39.29 and 18.22 respectively). Note that there are no significant levels attached to the fourth quarter effects as they are calculated from the first three quarters so that the sum of the seasonal effects is zero. The model suggests a statistically significant ($p < 0.05$, single tailed test) breathalyser effect causing the mean incidence rate to fall by 9.23 after the change in the law. The level of unexplained variation attributable to the model is 97.4 indicating an extremely good fit.

TABLE AI *Regression coefficients and explained variation for the incidence and case fatality models*

	TOTAL	12 midnight to 6 a.m.	6 a.m. to 12 noon	12 noon to 6 p.m.	6 p.m. to 12 midnight
INCIDENCE MODEL					
Mean Rate (1968)	226.12	20.22	24.61	56.44	48.48
Yearly Trend	4.31**	0.64**	0.86**	1.35**	0.56*
1st. Quarter	–48.65***	–5.41**	–1.28**	–9.66**	–12.97**
2nd. Quarter	– 8.86**	0.21	–3.44**	–2.04**	– 0.46
3rd. Quarter	39.29***	3.29**	1.39**	5.70**	8.82**
4th. Quarter	18.22	1.91	3.33	6.00	4.61
Breathalyser	– 9.23*	–2.35**	–0.24	–0.05	– 2.14*
Explained Variation (%)	97.4	97.1	93.5	96.7	98.6
CASE FATALITY MODEL					
Mean Rate (1968)	2.74	4.83	2.89	2.60	3.98
Yearly Trend	–0.09**	–0.10	–0.11	–0.11	–0.17**
1st. Quarter	–0.35***	–1.24**	–0.49**	–0.34**	–0.27**
2nd. Quarter	0.06	0.44**	–0.12	–0.19*	–0.20*
3rd. Quarter	0.23***	0.79**	0.68**	0.30**	0.16
4th. Quarter	0.06	0.01	–0.07	0.23	0.31
Breathalyser	–0.11	0.05	–0.29	–0.18	–0.08
Explained Variation (%)	89.7	87.3	80.2	79.5	82.1

NOTE: Incidence is expressed as a rate per 100,000 population per quarter.
Case fatality is expressed as a percentage.

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

REFERENCES

1. *Breathalyser Law in Canada* (excerpt from Criminal Law Amendment Act 1968-1969), 17-18 Eliz II, ch. 38, s., 16, p. 34, 1969.
2. MacMahon B, Pugh T. F., *Epidemiology: Principles and Methods*, Boston, Little, Brown and Company, 1970.
3. Newby R. F., Casualty Reductions in Great Britain – Following the Road Safety Act, 1967. *Transport and Road Research Laboratory, TRRL Technical Note TN 698,* April, 1973.
4. Newby R. F., (Road REsearch Laboratory, Buckinghamshire, England), Personal communication.
5. Ross H. L., Law, Science and Accidents: The British Road Safety Act of 1967. *The Journal of Legal Studies: the University of Chicago Law School*, 2(i), 1973.
6. U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States*, 1971.
7. Statistics Canada, *Causes of Death 1971*. Catalogue 84-203.
8. Statistics Canada, *1971 Census of Canada – Population Age Groups.* Catalogue 92-715.
9. Statistics Canada, *Motor Vehicle Traffic Accidents Quarterly*, 1963-1971. Catalogue 53-001.
10. Statistics Canada, Population estimates by Marital Status, Age and Sex, for Canada and Provinces, 1966 and 1970. Catalogue 91-203.

Law Enforcement Requirements for the Detection and Prevention of Drinking and Driving in Canada

John Hoday[1]

The Royal Canadian Mounted Police (RCMP) is the largest federal law enforcement agency in Canada. It is, therefore, involved in the many aspects of law enforcement duties on the federal level. Canada is divided geographically into ten provinces and two territories. The territories extend from the Atlantic to the Pacific Ocean above the ten provinces. There are more than 4,000 miles (6,400 km) between the two coasts of Canada. The RCMP is also the provincial law enforcement agency in eight of the ten provinces and in the Yukon and the Northwest Territories. The exceptions, on a provincial jurisdiction basis, are the provinces of Ontario and Quebec which have their own provincial law enforcement agencies. A major involvement of the RCMP is in the enforcement of federal and provincial statutes related to the field of traffic and traffic safety. We thus meet the public on the highways and also encounter the drinking driver.

The advent of the motor vehicle in substantial numbers occurred in the 1920s. The advent of the drinking driver occurred at the same time and the problem is still with us today. It is well recognized that over 50 per cent of our traffic fatalities are alcohol-related. In December 1969, an attempt was made to reduce the incidence of drinking-driving in Canada through the introduction of federal legislation. This legislation provided for compulsory breath testing (Breathalyzer) and stipulated that a blood alcohol concentration (BAC) of greater than 80 mg/100 ml in motorists was punishable. In my opinion, since that time, there has not been any improvement in the level of detection nor in the level of prevention of drinking drivers. It is true that there have been more impaired drivers apprehended each year and that more individuals have been charged and convicted each year as well. This is probably related to the proportional increases in the numbers of motorists and/or road-miles driven each year. If the increases in the number of individuals apprehended, charged and convicted, are only related to the increase in the number of motorists and/or road-miles driven per year, then we certainly have failed miserably in the field of detection and prevention of drinking-driving in Canada. It has been shown time and time again that heavy drinkers, *i.e.* those with substantial BACs continue to be overrepresented in motor vehicle accidents as compared to non-drinking drivers.

The intent of the 1969 legislation was to assist both the law enforcement officer and the courts in the identification, apprehension and conviction of the drinking-driver. It was intended to assist the law enforcement officer in determining whether or not a particular observed condition was the consequence of over-indulgence in alcohol, or was, in fact, due to an unsuspected medical condition. It also provided the courts with a scientific chemical test result which establishes a particular individual's BAC. These provisions have greatly assisted in the judicial processing of an individual who has been apprehended while driving a motor vehicle with a BAC in excess of 80 mg/100 ml. However, the provisions of the federal legislation have not reduced the occurrence of drinking and driving. The federal legislation referred to is as follows:

---

[1] Inspecting Officer in charge of Scientific Services, Royal Canadian Mounted Police, Ottawa, Canada.

> *Sec. 235 of the Criminal Code of Canada*
>
> *235 (1) Where a peace officer on reasonable and probable grounds believes that a person is committing, or at any time within the preceding two hours has committed, an offence under section 234, he may, by demand made to that person forthwith or as soon as practicable, require him to provide then or as soon thereafter as is practicable a sample of his breath suitable to enable an analysis to be made in order to determine the proportion, if any, of alcohol in his blood, and to accompany the peace officer for the purpose of enabling such a sample to be taken.*
> *235 (2) Every one who, without reasonable excuse, fails or refuses to comply with a demand made to him by a peace officer under subsection (1) is guilty of an offence punishable on summary conviction and is liable to a fine of not less than fifty dollars and not more than one thousand dollars or to imprisonment for not more than six months, or both.* (1)

> *Sec. 236 of the Criminal Code of Canada*
>
> *236. Every one who drives a motor vehicle or has the care or control of a motor vehicle, whether it is in motion or not, having consumed alcohol in such a quantity that the proportion thereof in his blood exceeds 80 milligrams of alcohol in 100 millilitres of blood, is guilty of an offence punishable on summary conviction and is liable to a fine of not less than fifty dollars and not more than one thousand dollars or to imprisonment for not more than six months, or both.* (2)

Despite these seemingly stringent measures introduced by the federal government to curb drinking-driving, no dramatic reduction has been experienced to date. There is still an alcohol-related involvement in over 50 per cent of fatal motor vehicle accidents! The average BAC determined through our breath testing program has not been lowered significantly, if at all, in some parts of Canada, since the implementation of the federal "Breathalyzer" legislation. It is readily apparent from Table I that the average BAC is still in the area of 170 mg/100 ml. Most of these are not impaired drivers, they are intoxicated drivers! Thus the average result of breath testing of the suspected drinking driver is more than double the legal limit of 80 mg/100 ml. Impaired drivers are not being readily detected. The question is, of course, why are drinking drivers with BACs between 80 mg/100 ml and 170 mg/100 ml escaping detection? The intoxicated driver readily reveals himself when confronted in either an emergency driving situation (accident) or in a routine road traffic check. The 'just' impaired driver remains an elusive entity, discernible solely by circumstances resulting from his involvement in an accident which has subjected him to closer scrutiny by a law enforcement officer. It is this 'just' impaired driver who is responsible for a great portion of motor vehicle accidents.

TABLE I *Breath-Test Statistics*

Province	Year	No. of Requests	No. of Tests	Mean BAC (mg/100 ml)
Alberta	1968	854	791	184
	1969	1,428	1,351	186
	1970	2,721	2,530	185
	1971	3,846	3,586	181
	1972	5,014	4,523	180
	1973	6,970	6,215	177
Saskatchewan	1970	3,982	3,767	160
	1971	5,645	5,218	160
	1972	6,399	5,668	165
	1973	6,022	5,391	170
Nova Scotia	1969		397[a]	
	1970	1,862	1,718	175
	1971	2,227	2,040	178
	1972	2,413	2,162	174
	1973	2,790	2,347	168
New Brunswick	1969		881[a]	
	1970	1,294	1,207	177
	1971	1,407[b]	1,297[b]	182
	1972	1,898	1,732	182
	1973	2,305	1,904	178

[a] Voluntary program prior to implementation of federal compulsory legislation December 1, 1969.

[b] Breath testing not compulsory during January, February, March, 1971, i.e. testing strictly on a voluntary basis.

It is evident that measures should be devised which will result in the reduction of the number of drinking drivers on our highways. This might be accomplished through the introduction of four positive programs:

1. Education of the police officer – training in the detection of the drinking driver. The policeman must be properly educated to detect the drinking driver in the stages before the driver demonstrates the gross physical symptoms of intoxication. The untrained officer is not oriented to detect the minute signs of alcohol impairment and he usually relies on the symptoms of intoxication used since time immemorial, such as slurred speech, glassy eyes, flushed face and related conditions. In fact, the "reasonable and probable grounds" criteria established by the policeman, before demanding a breath test, are usually so strong that an impaired driving conviction can be made using just the oral testimony of the policeman. Thus breath testing is not necessary when such gross symptoms are present. Our Breathalyzer operators are therefore exposed to as many aspects of the use of alcohol as is possible during their two-week training program. They are subjected to the basics involved in the physiology and pharmacology of alcohol. They appreciate what 80 mg of alcohol per 100 ml of blood means, through practical experience under controlled conditions. They are also made aware of what the drinking driver is experiencing on the highway and what he experiences in a breath testing situation in the confines of a police station. Perhaps such an educational program should be afforded to *all* law enforcement officers at some stage of their careers.

Also, the policeman should not only be in a position to detect the impaired driver, but should also be able to prevent the average citizen from becoming a prospective impaired driver. Thus the policeman should be taught how to work with the public in police-community relations programs.

2. The use of screening devices. The police officer, without an objective aid, cannot always relate such things as failing to maintain own lane, poor passing technique, driving too slowly, driving without headlights, failing to dim headlights, continually flashing signal light and other instances of bad driving to the probability that the driver is in an impaired condition. However, as long as no emergency presents itself, the 'just' impaired driver can cope with the situation and proceed from point A to point B without mishap. If an emergency does present itself, the probability of being involved in an accident increases dramatically and in direct proportion to the BAC of the drinking driver. Thus the policeman should have an objective investigative aid at the roadside to enable a proper decision to be reached as to whether a suspected drinking driver is operating in excess of the legislative limit or not. At the present time, the roadside situation still depends on a subjective assessment of the police officer. This assessment may result in no further action being taken to establish the actual BAC of the individual concerned if the previously described "reasonable and probable grounds" (gross physical symptoms) are not evident. Objective detection could be readily accomplished with the use of accredited screening devices. Such devices are, in fact, obtainable at this time and are being used to advantage in jurisdictions outside of Canada. Their use would have to be strictly on a voluntary basis, similar to the taking of a blood sample, in order not to infringe on the 'demand' for a subsequent Breathalyzer test. The results of the Breathalyzer testing would only be used for evidential value in court when the legislated limit is exceeded.

There are areas in Canada wherein provincial legislation allows the use of a screening device to assist the policeman in enforcing an immediate one-day (24 hour) licence suspension on-the-spot. No criminal charges are laid and no other penalty is imposed. However, the poor quality of the screening devices employed diminishes the effectiveness of this type of legislation. Furthermore, there is nothing to deter a person from returning to the road in a relatively short period of time, if he chooses, still suffering from the same impaired condition. To make the legislation effective, an additional deterrent or preventive measure is needed.

3. Legislation allowing compulsory screenings after traffic violations or accidents. Assistance could also be afforded to the law enforcement officer through the introduction of legislation which allows him to breath-test (screen) a driver involved in any moving traffic violation or accident. I understand that such legislation has been useful in the United Kingdom. The "reasonable and probable grounds" criteria presently used in Canada are too limiting to enable the detection of the 'just' impaired driver. Judgment and coordination are affected early as a result of drinking alcohol and this deterioration readily leads to traffic violations. Any use of a screening device would be facilitated through the introduction of appropriate legislation allowing their use. Otherwise, screening devices would be relegated to use on a voluntary basis and lose their effectiveness. At the present time, the courts could rule that such breath testing would fulfil the demand requirement of our Criminal Code, and thus preclude Breathalyzer testing for court purposes.

4. Public education programs. There is a definite need in Canada for an effective public education program. The public is not appreciative of the effects of alcohol on driving ability. They do not have a proper awareness of existing legislation and its intricacies. They are not fully aware of the consequences of the alcohol involvement in motor vehicle accidents. Police-community relations programs help in the fulfilment of the preventive aspect of policing. Efforts are made to try to deter the drinking driver by making him fully aware of his responsibilities as a motorist and the consequences of drinking and driving. Police community programs were conducted for the judiciary when breath testing was introduced into new areas. They were well received, very effective and very instrumental in the establishment of the Breathalyzer program in Canada. With the introduction of the federal Breathalyzer legislation in 1969, a massive information program was implemented by the federal government. This did have an immediate effect in reducing the incidence of drinking and driving, but it was short-lived. The province of Alberta has instituted an educational program for the public and a rehabilitation program for convicted drinking drivers. The public recognized the need for such action and have reacted positively to it. Only very recently, the province of New Brunswick has also instituted a program along similar lines.

SUMMARY AND CONCLUSION

As long as traffic fatalities, accidents and injuries are alcohol-related to the present degree, there must be effective programs to ensure that law enforcement officers can detect and prevent drinking and driving. There is a responsibility to the general public in this field, whether they appreciate it or not. I suggest that the necessary goals can be met through the areas of: 1) police education, 2) roadside screening devices, 3) legislation, and 4) public education. The order of listing is not necessarily the order of priorities to be established. Each is of prime importance in relation to the goals desired. The sooner any of these programs is implemented, hopefully in total, the sooner the involvement of alcohol in motor vehicle accidents will diminish. Such a decrease will result in fewer fatal motor vehicle accidents.

REFERENCES

1. *The Criminal Code (of Canada)*, Section 235, c. 38, s. 16, 1968-69. (Revised Statutes of Canada, 1970.)
2. *The Criminal Code (of Canada)*, Section 236, c. 38, s. 16, 1968-69. (Revised Statutes of Canada, 1970.)

Enforcement of the Law in Great Britain Regarding Motorists Impaired by Drink: Success and Problems

James K. McLellan[1]

In 1967, a new Act was passed which introduced for the first time the analysis of samples of blood or urine taken from motorists suspected of being impaired by alcohol. The conviction rate in Scotland has risen steadily since the inception of the Act as illustrated in Table I.

TABLE I *Drink-Driving Conviction Rates for Scotland*

1967	1968	1969	1970	1971	1972	1973
6,117	8,212	7,772	9,196	9,755	10,389	11,830

The success I wish to speak of, therefore, does not relate to the elimination or even the reduction of this offence but rather to the fact that the police officer can now proceed against the motorist impaired by drink with an ease and certainty which was not the case before the passing of this Act. Prior to this, without the benefit of analytical results, and often without the benefit of a medical examination, the police officer could look forward to a gruelling time in the witness box. Now many cases are not contested, those which are contested are decided mainly on the analyst's findings which are presented by a certificate without the analyst's being required to appear, except in rare instances where his presence is requested by the defence.

The police officer's main responsibility rests in identifying the person on trial as the driver or the person in charge of the vehicle who provided samples to be analysed for the prosecution (and the defence if so desired). The police officer's lay opinion of the accused's degree of impairment is no longer of great interest to the court since it is now a statutory offence to have an alcohol concentration in excess of 80 mg/100 ml.

Prior to 1967, for the purposes of establishing impairment by drink, blood or urine samples could only be taken from a suspected motorist with his consent. In 1967 a new Law was enacted, the Road Safety Act, which was later incorporated into the

---

[1] Chief Constable, Lanarkshire Constabulary, Lanarkshire, Scotland.

Road Traffic Act, 1972. Under this Act, while suspected motorists could refuse to supply samples, it became an offence, in certain circumstances, to fail to provide a sample of blood or urine for analysis.

The legislation against motorists suspected of being impaired by drink is in two parts, Section 5 and Section 6 of the Road Traffic Act, 1972. Section 5 deals with the impairment in the ability to drive due to drink (or other drugs) and Section 6 with the technical offence of having a concentration of alcohol in the blood in excess of 80 mg/100 ml.

This technical offence under Section 6 is established by:

1. A positive result when a suspect motorist gives a breath test on a breath test device at the road side.
2. A repeat of this positive result using the same type of device in the police station to which the motorist has been taken.
3. A blood sample taken by a doctor for subsequent analysis or two urine samples taken within an hour, the second of which is taken for analysis.
4. An analytical result in excess of 80 mg/100 ml or 107 mg/100 ml for urine, certified by an approved analyst.

The offence of driving while impaired is covered by Section 5 of the Act and involves drivers who normally have a much larger concentration than 80 mg/100 ml and in their case the roadside test is omitted and the driver is taken to a police station where matters proceed as for the technical offence.

Provision is also made for testing drivers involved in accidents and subsequently removed to hospital. In such cases the permission of the doctor in charge must be received.

In Scotland, England and Wales no legal use is made of quantitative breath testing devices but in Ulster (Northern Ireland) quantitative breath testing devices were carried and used in police vehicles as an alternative to the procedure prescribed. Due to the present emergency in that country the breath testing machine is now only used at police stations. The suspected motorist has a choice of having his alcohol concentration determined by this machine or by the taking of samples.

In Great Britain, the precise steps to be taken by the police under this Act are laid down and are to be carried out by police officers in uniform who have witnessed or have been informed of some irregularity of the motorist or his vehicle. In order that the provisions of the Act can be readily adhered to by police officers, a committee from the Association of Chief Police Officers (Scotland) produced a number of proforma to be used at police stations and at hospitals and these have been extremely successful in minimizing errors in procedure. Successful prosecution under the Act almost invariably carries a minimum disqualification of one year.

As I have already stated, the success of this Act has been more in connection with the ease in which it can be enforced than in the reduction of the number of occasions when motorists drive impaired with alcohol.

ENFORCEMENT OF LEGISLATION AGAINST IMPAIRED MOTORISTS

The Motorist Impaired by Alcohol

Since blood or urine samples are only sent for analysis following successful breath tests, one would expect the results obtained from the analyst to be either in the neighbourhood of 80 mg/100 ml or higher for blood and 107 mg/100 ml or higher for urine. Unfortunately, a study of the results received from the analysts throughout Scotland show that this is not the case and I believe a similar situation exists in England and Wales.

Within the last eighteen months this matter has been studied in an effort to reduce the number of samples being passed to the analyst which are found to be under the limit (Table II).

TABLE II *Proportion of Blood Alcohol Samples Containing under 80 and 50 mg/100 ml for the Years 1968-1973*

	1968	1969	1970	1971	1972	1973
Number of samples sent for analysis	8,019	9,667	10,702	12,224	14,028	15,253
Number of samples found to be under 80 mg/100 ml	891 (11.11%)	1,317 (13.62%)	1,600 (14.95%)	1,964 (16.06%)	2,349 (16.74%)	2,287 (14.99%)
Number of samples found to be under 50 mg/100 ml	292 (3.64%)	458 (4.73%)	563 (5.26%)	696 (5.69%)	875 (6.23%)	799 (5.23%)

I considered it worthwhile to have a serious examination made of cases where analytical results were found 50 mg/100 ml or below for the following reason: under the Act blood samples can only be taken by a doctor. In Scotland the doctor is summoned to the police station for this purpose when a successful breath test has been taken. While the doctors have some form of appointment with the police, few, if any, are retained on a full-time basis and the preponderance of calls for their services occur in the late hours of the evening or the early hours of the morning. There can, therefore, be delays of up to one hour in the arrival of the doctor which can mean that a person having passed his maximum concentration at the time of his apprehension could have this reduced by nearly 20 mg/100 ml while awaiting the arrival of the doctor. It is rare for delays to be in excess of one hour and consequently figures below 50 mg/100 ml require some explanation.

Among the possibilities considered have been:

1. *Failure on the part of the police officer to read the breath test device properly.* The reading device used in Great Britain is the Draeger Alcotest Tube containing a yellow mixture of potassium dichromate and sulphuric acid which changes to green during the oxidation of alcohol vapour. A concentration of alcohol in the breath in excess of 80 mg/100 ml should result in the green colour passing a marked line in the middle of the tube. The device is the best available for this purpose, but it is by no means as clear to read as a piece of litmus paper, particularly in poor artifical light at a roadside. Since the positive test at the roadside results in the motorist being brought to a police office for further testing, there should be no difficulty at any hour of day or night within the police station. Retraining of officers in the use of this device has substantially reduced, but not eliminated, the number of results being received from the analyst of under 50 mg/100 ml.

In Scotland, corroboration is required and two police officers are involved at the roadside and others at the police station could be asked to give an opinion. The question of defects in colour vision have also been considered and trials have been carried out with officers who have, in the past, been responsible for low results without anything significant being obtained. Breath testing devices were plugged with plasticine and were retained awaiting the analyst's results. The examination of these did not lead to any clear conclusion as to the reason for low results.

2. *A false positive breath test due to a continuance of the mouth effect or a recurrence of the mouth effect.* It is well known that even the tiniest trace of alcohol in the mouth will result in the mixture going completely green. Provisions are made to deal with this, particularly by means of the second breath test at the police station which provides sufficient delay for the elimination of this effect. Experiments have been carried out with persons wearing dentures to see if the mouth effect persisted for a long period with such persons following the drinking of spirits. This did not appear to be the case. A recurrence of the mouth effect due to regurgitation from the stomach would appear to be a possibility although not likely to account for the number of low results under consideration.

3. *An inaccuracy in the breath testing device.* Where a situation occurs which requires explanation one cannot neglect an examination of any of the apparatus involved. However, a visit paid to the place of manufacture convinced me that every effort was made to provide uniform reliable devices. These devices are not used if over one year old and, however they may be stored in the police car, are kept under reasonable conditions in the police stations where the decisive test is taken. All checks made on these devices during field trials have not produced examples of devices from different batches showing markedly different readings under the same conditions. The manufacturers, in their literature, describe the reaction in the device as a conversion of alcohol to acetaldehyde. In actual fact the reaction proceeds to some extent to acetic acid. It does not appear that moisture in the breath causes any great variation in the extent to which oxidation proceeds.

Another matter, which the author has not had the opportunity to consider, is the reliability of the equilibrium of alcohol in the body of 0.75/1/2100 between urine, blood and breath, but the variation in the equilibrium from the figures would need to be gross to account for the very low analytical results following successful breath tests.

The Motorist Impaired by Other Drugs

A further problem in connection with impaired motorists is the fact that legislation enacted in 1967 is only concerned with impairment due to alcohol and does not in any way relate to other drugs. The attention of police officers is directed to other drugs, particularly where they are of the opinion that motorists are impaired and the breath test proves negative. The current legislation only provides that the motorist should be requested to give a sample for analysis. The police officer has to remamber to ask the doctor for a sample very much larger in quantity than the 1 ml sample required for alcohol. The conviction rate for the misuse of drugs has been rising steadily in Scotland and Great Britain over a number of years. The conviction rate for a motorist impaired by alcohol has been rising over a number of years but it is possible that in the whole of Great Britain during 1973 no more than 40 motorists would be convicted of driving whilst impaired by other drugs. It is probable therefore that the facile legislation to deal with alcohol and the absence of any legislation and any methods to assist in the detection of motorists impaired by other drugs has led to a situation where this class of offender is escaping attention.

The Use of a Screening Test for Drinking Drivers in Conjunction with an Automatic Data Processing Unit

R. T. Hawthorne[1]

In December, 1968, legislation was enacted in the State of New South Wales, Australia, making provision for the chemical breath testing of drivers of motor vehicles in specific circumstances. At the time of introduction, legislation of a similar nature was already in force in most other States of Australia. The enactment provides that a driver of a motor vehicle may be subjected to a roadside screening test, using "Alcotest"[2] equipment, if (a) he has committed any breach of the Motor Traffic Acr or Regulations while driving or (b) he is involved in a motor vehicle accident. A driver may also be subjected to the test if a member of the police force has reasonable cause to believe that he has alcohol in his blood because of the manner in which he drives or attempts to set a motor vehicle in motion.

The legislation also provides that the police should not require a person to undergo a breath test or submit to a breath analysis if the driver has been admitted to hospital for medical treatment and the doctor in immediate charge objects on the grounds that to comply would be prejudicial to the proper care or treatment of the person. However, if the medical practitioner has been notified by the police of their intention to perform a breath test and the practitioner does not object, solely on these grounds, then the person would still be required to undergo the test. Also, the legislation does not require a person to undergo the breath test or analysis if it appears to the member of the police force concerned that, as a result of injury sustained, it would be dangerous to the person's medical condition. Other circumstances in which a person is not required to take the test would be if two hours had elapsed since the event that inspired the test and if the person had returned to his usual place of abode.

In order to facilitate the enforcement of this legislation, it was decided that two separate forms of breath tests were to be undergone by motor vehicle operators. The first test, which is commonly referred to as the "Roadside Screening Test", is conducted using the "Alcotest" equipment referred to above, and is designed for use by police officers who have no specialised training. This test will indicate with a reasonable degree of accuracy whether or not the driver tested may have the prescribed blood alcohol concentration, *i.e.*, a blood alcohol concentration of 80 mg/100 ml. If this screening test results in a positive reaction, if the driver refuses to undergo the test, or, if the driver does not supply the sample of breath in accordance with the directions of the member of the police force, he is arrested and required to submit to a breath analysis, using the Borkenstein "Breathalyzer"[3]. This instrument is only operated by specially trained police who have undergone an intensive course of instruction, followed by written and oral examinations, practical tests and a searching viva voce examination before being approved by the commissioner of police to perform this phase of duty. The blood alcohol concentration determined using the "Breathalyzer" instrument is the evidence placed before a court. If, when a driver undergoes a breath analysis, a blood alcohol concentration of less than 80 mg/100 ml is determined, no further action relating to the drink-driving offence is taken but in the majority of cases the driver is dealt with for the original traffic violation which brought him under police notice.

---

[1] Assistant Officer in Charge, New South Wales Police Department, Breath Analysis Section, Sydney, Australia.

[2] "Alcotest R80", manufactured by Drager Normalair Ltd., Blyth, Northumberland, England.

The legislation also provides that an offence be created if a driver does anything to wilfully alter the concentration of alcohol in his blood between the time when he could be required to undergo a breath test or analysis and the time when he is actually required to undergo a breath test or analysis. A driver who refuses to undergo the roadside test is liable to a fine of up to 200 dollars. Should the driver refuse to undergo a breath analysis he is liable to a find not exceeding 400 dollars and/or a period of imprisonment for 6 months with hard labour. The driver also receives a mandatory licence disqualification for a period of 12 months. Drivers convicted on a second occasion within a period of 5 years may have a licence disqualification of 3 years imposed.

ENFORCEMENT PROCEDURE

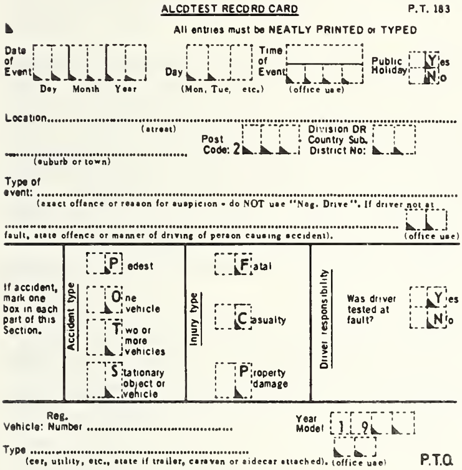
In the State of New South Wales, all mobile police units, of which there are 2,250, carry "Alcotest" equipment. Should the police manning these units subject a person to a breath test and the test indicate a 'positive' reaction, the driver is arrested and taken to a place, usually a police station, for a breath analysis using "Breathalyzer" equipment. Breathalyzer operators, carrying the necessary equipment and using specially equipped vehicles, with which roadside analyses may be conducted, maintain constant patrols throughout the more densely populated areas of the state. The state has an area of 309,433 square miles and a population of 4,589,000, mostly inhabiting the eastern portion of the state. It is possible for these police to conduct breath analyses at virtually any location, as they are in constant radio communication with their nearest base and can be directed expeditiously to the site of a proposed analysis.

RECORD OF "ALCOTEST" – DATA CARD

At the time of the introduction of the enforcement programme in New South Wales to detect drink-driving offenders it was realised that an unparalleled opportunity existed for the collection and correlation of unique and pertinent data. A vast amount of information became available which is of inestimable value not only to the facilitation of the enforcement programme but also as a supply of information of a sociological nature. After consultation with all interested bodies it was decided that available information should be gathered at root level, *i.e.*, at the point of interception of the

[3] Borkenstein "Breathalyzer", manufactured by Smith and Wesson Electronic Company, Eatontown, New Jersey, U.S.A.

motor vehicle driver concerned, with additional information being added as the particular individual driver was processed. A raw data card was prepared (Figures 1 and 2). All data included on the double sided card are coded and ultimately stored in the automatic data processing unit. The information is gathered by the apprehending police officer on each occasion a driver is subjected to a roadside screening test, so that notwithstanding the result of the test, comprehensive information is available relating to every driver apprehended.



ALCOTEST RECORD CARD P.T. 183

All entries must be NEATLY PRINTED or TYPED

Date of Event ☐☐ ☐☐ ☐☐ (Day Month Year)
Day ☐☐☐ (Mon, Tue, etc.)
Time of Event ☐☐☐☐ (office use)
Public Holiday ☐ Yes ☐ No

Location .... (street)
.... (suburb or town)
Post Code: 2☐☐☐
Division OR Country Sub. District No: ☐☐

Type of event: .... (exact offence or reason for suspicion - do NOT use "Neg. Drive". If driver not at fault, state offence or manner of driving of person causing accident). ☐☐ (office use)

If accident, mark one box in each part of this Section.

Accident type: ☐ Pedest ☐ One vehicle ☐ Two or more vehicles ☐ Stationary object or vehicle

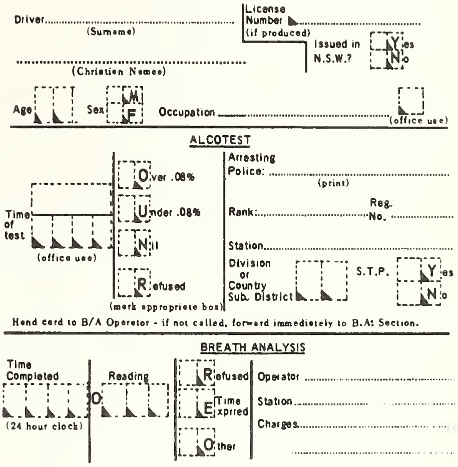
Injury type: ☐ Fatal ☐ Casualty ☐ Property damage

Driver responsibility: Was driver tested at fault? ☐ Yes ☐ No

Vehicle: Reg. Number ....
Year Model 1 9 ☐☐
Type .... (car, utility, etc., state if trailer, caravan or sidecar attached). ☐☐ (office use)

P.T.O.

Figure 1 *Alcotest record card side 1*



Driver .... (Surname)
.... (Christian Names)
License Number .... (if produced)
Issued in N.S.W.? ☐ Yes ☐ No
Age ☐☐ Sex ☐ M ☐ F Occupation .... ☐ (office use)

ALCOTEST

Time of test ☐☐☐☐ (office use)
☐ Over .08% ☐ Under .08% ☐ Nil ☐ Refused (mark appropriate box)
Arresting Police: .... (print)
Rank: .... Reg. No. ....
Station ....
Division or Country Sub. District ☐☐
S.T.P. ☐ Yes ☐ No

Hand card to B/A Operator - if not called, forward immediately to B.A. Section.

BREATH ANALYSIS

Time Completed ☐☐☐☐ (24 hour clock)
Reading 0.☐☐☐
☐ Refused ☐ Time Expired ☐ Other
Operator ....
Station ....
Charges ....
....

Figure 2 *Alcotest record card side 2*

It was appreciated at the commencement of the programme that the scope for gathering information was vast. Hence, the various categories to be studied were limited to an area which would coincide basically with data being gathered by other workers in this field in Australia, particularly by the Traffic Accident Research Unit, which forms part of the Department of Motor Transport in New South Wales. This enables comparisons to be made between the known drink-driving population and the driving population generally. It can be seen from Figures 1 and 2 that the majority of the information gathered is self-explanatory. The sections of the card depicted in Figure 1 relating to the location of the apprehension give both the Police Administrative District and the postal service code. Since postal service code divides the entire state into 649 separate areas, the location of these offences can be pinpointed with great exactitude.

The circumstances leading to the interception of the driver are separated into 41 categories (Appendix A) which include either a specific driving or roadworthiness offence, or a description of a manner of driving which brought about the subsequent apprehension of the motor vehicle driver. The type of motor vehicle driven is separated into 25 categories (Appendix B) and occupations into 10 categories (Appendix C). These classifications basically divide the drivers concerned into professional, white collar and blue collar groups. The information contained in the data card is available on request to approved groups in the various fields inquiring into this particular social problem. The data can be supplied in any configuration required, e.g., age, occupation, type of motor vehicle, age of motor vehicle, time of offence, day of offence. Action has recently been taken to provide for the inclusion of names and the date of birth of offenders in the data recorded by the automatic data processing unit. Information relating to recidivism up to this time has only been available from the frequency of court appearances. This information is at present only available from statistics compiled by the New South Wales Department of the Attorney General and the Department of Justice. The added information gathered at the point of detection will greatly facilitate the gathering of data, particularly that concerning multiple offenders at the lower blood alcohol levels. It is intended that this aspect, if it appears significant, will be the subject of a future long range study. Birrell (1) supports this proposal and has indicated that "it should be remembered that a negative blood alcohol level may be just as important as a positive one."

The interest shown in the information which covers breath testing activities gathered in New South Wales from January 1, 1972, has not been as intensive as was anticipated at the introduction of the programme, whether through lack of knowledge of the information available, or lack of interest in this particular type of information. There appears to be a tendency in some regions for the various groups concerned with this problem to work independently of each other. Only recently has action been taken in Australia to provide a central agency which will be in a position to coordinate various activities in the drink-driving research field. In the past, persons inquiring into the drink-driving problem appear to have developed to some extent a habit of jealously guarding almost any information gained as their own personal property. In my opinion sufficient preliminary information is already on hand to provide guidance and assistance to workers and legislators in their endeavours to combat this very real social disease. It remains basically a question of all concerned using the data available to the best possible advantage.

The basic information, for enforcement/management is made available by a monthly computer 'print-out' which gives a graphic picture of the individual activities of police in 35 Metropolitan Police Divisions and 35 Country Sub-District Areas, which covers the entire State of New South Wales.

The print-out is divided into two halves. The left half deals with roadside screening tests, the right with breath analyses. From the left side, information is set out which indicates the police division number, the month, year to date totals, total tests, those found to be positive, those found to be negative, refusals, those conducted by special traffic patrol police and those tested on public holidays. The last 4 columns on the left side of the page depict information relating to accidents, *i.e.*, total accidents, fatalities, casualties and property damage. The right half of the print-out sets out information relating to breath analyses; firstly, total analyses. The next two columns set out the breakdown of 'positive' analyses; the first indicating those 0.150 and over, and 0.080 to 0.150. The following two columns set out the breakdown of 'negative' analyses, the first indicating readings of 0.050 to 0.080 and the second readings under 0.050. The next column indicates refusals, *i.e.*, persons who refuse to undergo the breath analysis or fail to supply the required breath sample. The "No B/A" column shows the number of analyses not conducted, which is usually for some medical reason or because the legal time limit to conduct the analysis may have expired. The remaining columns separate males and females, those 25 and over and those under 25. In addition, at the end of each computer report, statistics are supplied of the number of "Alcotest" tubes used in each Division or Sub-District during the current year, from 1st January.

The following information is supplied as an indication of the type of data which is readily available. During 1973, a total of 27,601 motor vehicle drivers were subjected to a roadside screening test by police in the State of New South Wales. Of these

83.5% were 'positive' and 2.1% refused to undergo the breath test. Subsequently, of the 23,654 subjected to a breath analysis 43.3% were found to have a blood alcohol concentration of 0.150 or more, 35.8% were found to have a concentration between 0.080 and 0.150, and 1.65% refused to undergo the breath analysis. The remainder were found to be 'negative'.

Of the total, 23.7% or 6,564 were tested as a result of being involved in a collision, 5,235 were involved in collisions which resulted in property damage, 1,247 in collisions where a person was injured and 82 in collisions which resulted in a fatality. During 1973 in the State of New South Wales, 117,206 motor vehicle collisions were reported to police. As a result of these collisions, 1,181 persons were killed and 38,301 were injured. From the foregoing statistical information it would seem that insufficient emphasis is being placed on the collision-involved driver. This is in some way contributed to by the undue length of time taken by some drivers to report these incidents to the police, so that, because of legislative requirements, breath tests are not made. Of course, the isolated location of some areas in which collisions occur and the non-availability of breath testing equipment also adds to this problem. Many other circumstances exist which make it impracticable to utilise breath testing equipment.

In certain States of Australia action is being taken to legislate for the compulsory extraction of blood samples from all accident-involved persons, by medical practitioners providing treatment for injuries received. In addition, statutory power is being provided to enable blood samples to be extracted, by medical practitioners, when injuries received preclude the supply of a breath sample. It is felt that this type of legislation will contribute greatly to the efficacy of enforcement of this particular type of offence. It will also greatly assist the gathering of pertinent statistical information which would otherwise be lost.

CONCLUSION

Experience gained in New South Wales has left no doubt that in a programme of any significant size designed to combat the incidence of drink-driving, with its subsequent horrifying results, the use of an automatic data processing unit to correlate the abundance of information available is essential. In 1973 in New South Wales, 27,601 drivers were subjected to screening tests and 23,654 were subjected to subsequent breath analyses. It would be a practical impossibility to collate the information available manually. With the information supplied by computer, the law enforcement agency concerned is able to marshall its resources to the best and most efficient possible advantage, e.g., at high risk spots in various localities and at times and on days when the problem is at its peak. The activities of police throughout the enitre State of New South Wales is clearly set out at monthly intervals by computer print-out for the information of senior police officers and subsequently the entire management and enforcement in this field is brought to a practical level which would not otherwise be attained.

As an added benefit in the State of New South Wales, the information supplied by the automatic data processing unit is utilised as a stock control method and to a large extent provides a safeguard against possible improper use of the equipment in the field.

There is no doubt that the vast amount of ground work already covered should provide sufficient incentive for all authorities concerned to generate some positive activity. The information gathered by the system developed in New South Wales, Australia, can only serve to support positive steps taken by law enforcement agencies, by workers in the field and by legislators in their most difficult task of combating this very real social disease.

APPENDIX A

OFFENCE

Driving	*Offence Number*
Drive manner dangerous	01
Drive speed dangerous	02
Negligent driving (single vehicle and rear end collisions etc. where no specific offence)	03
Drive manner indicating excess alcohol (weaving etc.)	04
Drive disqualified/suspended	05
Drive cancelled/refused	06
Not stop after accident	07
Exceed speed limit	08
Unlicensed driver	09
Driving hours (heavy vehicles)	10
Provisional license offences (excluding E.S.L.)	11
Drive contrary to notice	12
Disobey traffic control light	13
Not keep left	14
Cross centre line at grade or curve	15
Separation line offences	16
Lane line offences	17
Not give way to vehicle on right	18
Not give way at marked footcrossing	19
Overtake vehicle at marked footcrossing	20
Disobey stop sign	21
Not make right hand turn with safety	22
Overtake nearside	23
Incorrect right turn	24
Incorrect left turn	25
Unlawful ‘U’ turn	26
Not signal intention	27
Not leave curb with safety	28
Not have proper control	29
Not dip headlights	30
Body protrude	31
Carry pillion passenger	32
Miscellaneous driving offences	33
Offence not determined	34

Equipment	
Brakes offences	40
Tyre offences	41

Inefficient silencer	42
Head lamp offences	43
No rear light	44
Reflector offences	45
Number plate offences	46
Miscellaneous equipment offences	47

APPENDIX B

TYPE

Motor Vehicles	*Code*
Car	01
Car and box or other small trailer	02
Car and caravan	03
Utility, small panel van, station waggon and jeep	04
Utility etc., with trailer	05
Lorry including large van, pantechnicon	06
Lorry and small trailer	07
Semi-trailer	08
Lorry and large trailer	09
Low loader or goose-neck float	10
Omnibus – Government Transport	11
Omnibus – other	12
Taxi-cab or hire car	13
Self propelled plant, e.g., mobile crane, tractor, road roller	14
Detached trailer	15
Other motor vehicle	16
Ambulance	17
Any Fire Brigade vehicle	18
Blood bank vehicle	19

Motor Cycles

Solo	21
With pillion passengers	22
With sidecar or sidebox	23
Motor scooter (includes autocycle)	25
Motor scooter with pillion passenger	26
Motor scooter with sidecar or sidebox	27

APPENDIX C

OCCUPATION CODES

Occupation	*Code*
Unstated	0

OCCUPATION CODES

Occupation	*Code*
Professional (University Qualifications Only – doctors, dentists, lawyers etc.)	1
Skilled and Sub-Professionals (trade qualifications, plumbers, mechanics etc.)	2
Unskilled (labourers, etc.)	3
Taxi, omnibus, truck drivers etc. (professional drivers)	4
Commerce and Office Workers (company directors, clerks, typists, etc.)	5
Sales Worker (shop assistants, commercial travellers, etc.)	6
Armed Services	7
Retired – (include domestic duties, i.e., housewife, and pensioners)	8
Student	9

REFERENCES

1. Birrell, J.H.W., Drinking, Driving and You, Sun Books, Melbourne, Australia, 1974.

Compulsory Blood Alcohol Determinations in Road Crash Casualties: Experience Following Recent Australian Legislation

B. S. Hetzel[1], G. A. Ryan, F. McDermott and E.S.R. Hughes.

The development of legislation regarding blood alcohol concentration (BAC) and road safety is an interesting contemporary example of the social application of scientific findings. As in other public health problems, such as the compulsory treatment of pulmonary tuberculosis, issues of individual freedom have had to be faced. It is apparent that there is a limit to the price that can be paid by modern societies for individual freedom in the case of road safety and its significant relationship to alcohol consumption.

We will review briefly the development of Australian legislation before considering in detail recent findings on blood alcohol levels in traffic casualties. Particular reference will be made to the two Australian States of Victoria (population 3.5 million) and South Australia (population 1.1 million). Both have established some Australian landmarks in progressive legislation. Victoria was the first Australian state to legislate for compulsory crash helmets on motor cyclists (1961) and the first Western community to make the wearing of safety belts compulsory (1971). South Australia has freed the alcoholic causing social disturbance from court jurisdiction and police charges.

THE DEAD DRIVER

Australian legislation regarding alcohol and road safety followed initial studies of BACs in dead drivers carried out by pathologists such as Bowden (3) and Birrell (1) in Victoria. They both reported that about one-third of motor car drivers killed have BACs in the area of 100 mg/100 ml. Most recent information on the situation in Victoria is available from Hossack (7). In 1972, Hossack found 60% of 171 dead drivers showed detectable blood alcohol; 17 between 30 and 100 mg /100 ml, 48 between 100 and 200 mg/100 ml, 30 between 200 and 300 mg/100 ml, and 7 between 300 and 400 mg/100 ml. In all, 50% of the drivers had levels greater than 100 mg/100 ml. Similar findings (45.7%) were reported by Tonge (14) in Queensland from an analysis of 199 car drivers killed between 1963 and 1968. Tonge also found levels in excess of 100 mg/100 ml in 25.5% of 278 dead pedestrians, in 19.8% of 156 dead car passengers, and in 25.0% of 28 dead motor cyclists over the same period. In two-thirds of drivers involved in single car crashes, BACs were noted to be in excess of 100 mg/100 ml; in half, levels were in excess of 200 mg/100 ml.

---

[1] Department of Social and Preventive Medicine, Alfred Hospital, Victoria, Australia.

BREATHALYSER LEGISLATION

In 1966, the recommendations of the Victorian State Royal Commission on Liquor were implemented (11). These required the breathanalysis of all drivers suspected of being under the influence of alcohol. The level of 50 mg/100 ml was determined to be the maximum permissible level so that the finding of a level above this in a driver was an offence. The other States of Australia duly followed Victoria but recommended a level of 80 mg/100 ml, as in the case in the United Kingdom. These recommendations took into account the findings of Borkenstein and Dale (2) in the U.S.A. following observational studies which revealed that the risk of accident increases sharply as the BAC rises above 50 mg/100 ml. At this level, the risk was 1.2 times as great, increasing to 1.5 times at 70 mg/100 ml, and six times at 100 mg/100 ml. Most of us in Victoria are convinced of the desirability of the 50 mg/100 ml level in contrast to the more prevalent 80 mg/100 ml.

Analyses of the BACs of breathalysed drivers from all Australian States have been published (10). In Melbourne, of 8,550 breathalysed drivers, 65% were in excess of 150 mg/100 ml. It is agreed that such levels would not be attained with normal social drinking and that they indicate a drinking problem (1, 8, 12). These levels indicate a high degree of tolerance to alcohol which can only come from sustained heavy drinking over a number of years.

Recently, efforts to develop a rehabilitation program for young drivers convicted with BACs in excess of 50 mg/100 ml have been initiated by Dr. J. Santamaria at St. Vincent's Hospital, Melbourne, along the lines suggested by Stewart and Malfetti (13).

BLOOD ALCOHOL IN TRAFFIC CASUALTIES

Of course, most traffic crashes result in injury, not death. In 1972 there were 814 fatal accidents in Victoria out of a total of 14,757 accidents involving personal injury reported to the police. However, there has been no systematic data on BACs in non-fatal casualties.

A preliminary study of BACs of all patients admitted to a casualty department in a large Melbourne hospital over a period of 7 days (6) revealed no less than 30% with detectable levels (75 of 245 patients tested). Of these, 21 had levels in excess of 150 mg/100 ml. Fifty-eight of these patients were involved in motor car accidents and in these 27 had detectable blood alcohol, 6 of them 150 mg/100 ml or more. It was apparent that the hospital was indeed 'a haven for the alcoholic' if he had the 'good fortune' to be injured with a BAC in excess of 50 mg/100 ml because he came under the protective influence of medical confidentiality. At the same time, it was apparent that a knowledge of the BAC would be of great help in the management of an unconscious patient and also in the identification of a drinking problem which could be treated at a much earlier stage than that usually presented in current medical practice.

It was for these reasons that in 1970 the Victorian State Parliament Select Committee on Road Safety recommended the compulsory blood alcohol testing of accident victims. No action, however, resulted. Subsequently, in 1972, the Federal

Government's Expert Group on Road Safety made a similar recommendation, but this was also ignored.

In 1968, the Australian Medical Association made a policy statement and the Royal Australasian College of Surgeons Road Trauma Committee became unofficially organized. The Road Trauma Committee was formally set up in 1970 with the declared aim "to maintain surveillance of the incidence and patterns of injuries, of measures available for their prevention and relief, and of organization for the application of these measures". The Committee has a representative from each State and New Zealand, the Chairman being E.S.R. Hughes, and the Deputy Chairman Grayton Brown, and subsequently Gordon Trinca. This Committee, together with the State Parliamentary Committee on Road Safety must be given the credit for the decision to introduce compulsory seat belt wearing in Victoria in 1970.

The Road Trauma Committee, fresh from its triumph with the adoption of compulsory seat belts, set up a working party to study the problem of BACs in accident victims. This was based in South Australia under the Chairmanship of Mr. Donald Beard. The working party included a neurosurgeon, a forensic pathologist, the State President of the Australian Medical Association, the police, the Crown Solicitor, a representative of the Law Society, the Minister of Roads and Transport and his Secretary, and the Medical Superintendent of the Royal Adelaide Hospital.

The working party also came to the conclusion that compulsory testing was necessary. It recommended that all occupants of the motor vehicle should be tested because it was wrong to place the onus of identifying the driver on the doctor in Casualty. Furthermore, it should be compulsory in order to avoid penalizing the unconscious patient who cannot exercise a right to refuse. In addition, there has been provision by statutory declaration for the doctor who refuses to take the blood on grounds of conscience as interference with the patient's management. It was agreed that it is not possible by rapid clinical observation alone in casualty departments to determine in advance whether or not a patient has an elevated BAC. The Swedish experience with random testing at road blocks indicated that police could not readily detect evidence of impairment in 50% of drivers with blood alcohol concentrations in the range of 100 to 150 mg/100 ml (4).

The conclusions of the working party became the policy of the Royal Australasian College of Surgeons in October, 1972. It became the law in South Australia in August, 1973. The legislation was passed in Victoria in April, 1974 and became law on April 8, 1974.

In South Australia, refusal to permit a blood sample to be taken leads to a fine of $100; in Victoria such refusal must be followed by a statutory declaration by the doctor, and the patient may be fined up to $200.

In South Australia, the blood samples are taken by casualty doctors, the case sheet stamped, and then the samples stored in a locked non-refrigerated box until collected at 24 hour intervals by a police courier service which transports the sample to the State Chemistry Laboratory for analysis. Results are available within 24 hours if necessary. Not all hospitals have been included so far, as there would be obvious difficulties in smaller rural hospitals. At present, approximately 600 samples are being analysed each month.

In Victoria, considerable initial logistic difficulties arose as a result of cumbersome and inadequate arrangements, particularly for transport of samples to the medico-legal laboratory at the Coroner's Court. However, these difficulties are now being overcome and now approximately 3,000 samples are processed each month. Refusals have been very few (only 2 out of 466 in the first series in Victoria).

Three aliquots are taken, one for the hospital, one for the police and one for the patient. The hospital sample is tested within 3 days at the medico-legal laboratory and the result made available immediately to the hospital as an aid to management and to the police. The police sample taken from drivers found to have BACs greater than 50 mg/100 ml is then collected from the hospital by the police and the determination repeated in the Police Forensic Laboratory for legal purposes. The patient sample is kept for 90 days if the police collect their sample. Only samples collected within 2 hours of the accident are accepted for legal purposes at present, although samples are obtained up to 8 hours after the accident. Blood alcohol determination is carried out using the gas chromatograph (5).

FINDINGS

Victoria

Preliminary findings are presented on a series of 466 patients sampled from casualty departments in three Melbourne hospitals during April-May, 1974. As would be expected, there is an excess of samples on the weekend and in the evenings. The initial series of 466 patients comprised 27.8% drivers, 37% passengers, 6.8% motor cyclists, 3.0% bicyclists and 12.4% pedestrians. Of these, 40.7% were in the 20 to 29 year age group, 21.9% in the 10 to 19 year age group; and 15.3% were between the ages of 30 and 39. There was a majority (62.3%) of males. In 75% of cases the injury was classified as minor, in 14.6% the injury was major, and there was none in 5.6%; 16.8% of patients were admitted to hospital beds.

In 31% of 209 of these patients blood alcohol levels were detected; 13.9% in excess of 50 mg/100 ml, 4.8% had levels between 50 and 99 mg/100 ml, 2.4% between 100 and 149 mg/100 ml, and 6.7% were in excess of 150 mg/100 ml.

TABLE I *Blood Alcohol Concentrations in Traffic Casualties*

BAC	Three Melbourne Hospitals[a]	Melbourne Metropolitan[a]	South Australia[d]
	N	*N*	*N*
Nil	148	533	452
0 - 49 mg/100 ml	32	7	30
50 - 79 mg/100 ml	5	11[b]	18
80 - 149 mg/100 ml	10	27[c]	54
> 150 mg/100 ml	14	22	50
TOTAL	209	600	604
	Percentage	*Percentage*	*Percentage*
% Detectable	31	11	25
> 50 mg/100 ml	14	10	22
> 150 mg/100 ml	6.7	3.7	8.4

[a] Excludes 5% of samples with high levels held by Victoria Police.

[b] 50 - 99 mg/100 ml

[c] 100 - 149 mg/100 ml

[d] January, 1974

In the first 600 samples processed from all Melbourne metropolitan hospitals, 67 (11%) had detectable blood alcohol, of which a) only 7 were less than 50 mg/100 ml, b) 11 were between 50 and 99 mg/100 ml, c) 49 had levels of 100 mg/100 ml or more, and d) 22 had levels of 150 mg/100 ml or more (Table I).

A comparison of the levels in the Melbourne casualty series with those previously reported in Victorian breathalysed drivers (9) involved in accidents and dead drivers (7) is shown in Table II. Levels in the hospital casualties were lower than in the breathalysed or dead drivers.

TABLE II *Comparison of Detectable Blood Alcohol Concentrations in Victorian Road Casualties.*

	0 - 99 mg/100 ml	100 - 199 mg/100 ml	200 - 299 mg/100 ml	300 mg/100 ml +	Total
Fatal Casualties[a]					
Drivers	17	48	30	8	103
Passengers	14	21	13	3	51
TOTAL	31 (20.1%)	69 (44.8%)	43 (27.9%)	11 (7.1%)	154
Melbourne Hospital Casualties					
Three large hospitals	43	13	6	–	62
Metropolitan area	18	39	9	1	67
TOTAL	61 (47.2%)	52 (40.3%)	15 (11.6%)	1 (0.8%)	129
Breathalysed Drivers[b]					
Accident	21	124	86	8	239
Non-accident	31	139	60	7	237
TOTAL	52 (10.9%)	263 (55.3%)	146 (30.7%)	15 (3.2%)	476

[a] Hossack (7) [b] Raymond (9)

South Australia

Each month over 600 samples are processed, mostly from Adelaide metropolitan hospitals, with approximately 25% of them showing detectable blood alcohol. Forty of these (25%) had levels of 150 mg/100 ml or more. So far, only certain selected large hospitals are providing samples[2].

Comparison of the range of levels seen in the hospital casualty subjects reveals higher levels in the Big Melbourne Hospital series compared with the Melbourne Metropolitan area (Table I). The levels in the South Australian series, also taken predominantly from city hospital populations, reveal slightly higher levels than in the Melbourne hospitals. More samples are required to confirm any of these differences.

DISCUSSION

The magnitude of the road toll and the realization of its connection with alcohol consumption has brought about the development of the legislation for compulsory blood alcohol determinations on road crash victims presented to hospital casualty departments. The passage of this legislation in Australia has depended in the first place on adequate scientific investigation followed by sustained pressure and effort by the medical profession, notably surgeons through the Royal Australasian College of Surgeons.

---

[2] We are indebted to Mr. Donald Beard of Adelaide for the information concerning South Australia.

Initial experience indicates a frequent association of elevated blood alcohol levels with road crash victims seen in hospital casualty departments. A significant proportion (6-8%) of these casualties have grossly elevated BACs, 150 mg/100 ml or more. Other evidence indicates such subjects have long standing drinking problems (1, 8, 12). Further studies of drinking patterns in these subjects are in progress to confirm this expectation. If confirmed, new methods for education and rehabilitation will need to be devised. The availability of these results has opened new prospects for early removal of the problem drinker from the road and his early treatment. The final step, random testing at peak periods, is to be introduced in Holland and Sweden for 1974 and has now been proposed later this year for Victoria.

REFERENCES

1. Birrell, J.H.W., Blood alcohol levels in drunk drivers, drunk and disorderly subjects and moderate social drinkers. *Med. J. Aust.* 2, 949 (1965).
2. Borkenstein, J. and Dale, A. *Drinking Driver in Traffic Accidents.* Indiana University, Bloomington, Indiana, 1964.
3. Bowden, K. M., Wilson, D. W., Turner, L. K., A survey of blood alcohol testing in Victoria (1951-1956). *Med. J. Aust.* 2, 13 (1958).
4. Browne, G. Personal communication, 1973.
5. Finkle, B. S., Ethanol., Type C Procedure. In *Manual of Analytical Toxicology*, Irving Sunshine (ed). The Chemical Rubber Co. Press, Cleveland, 1971.
6. Gay, J. J., Coates, R. L., Coggins, G. L., Alexander, K. D., Nayman, J. Blood alcohol concentrations upon admission to a Hospital Casualty Department. *Med. J. Aust.* 2, 778 (1970).
7. Hossack, D. W., Investigation of 400 people killed in road accidents with special reference to blood alcohol levels. *Med. J. Aust.* 2, 255 (1972).
8. Rankin, J. G., The effects of alcohol on driving efficiency. *Med. J. Aust.* 2, 718 (1967).
9. Raymond, A., Drivers breathalysed in Melbourne in 1969. *Proc. Australian Road Research Board* 5, 209 (1970).
10. Robertson, J. S., *Blood Alcohol Concentrations in Drivers Breathalysed by Police in Six Australian States.* National Road Safety Symposium, Dept. of Transport, Canberra, 1972.
11. *Royal Commission into the Sale, Supply, Disposal or Consumption of Liquor in the State of Victoria (1964-1965).* Government Printer, Melbourne.
12. Santamaria, J. N., Treatment of the drinking traffic offender. *Med. J. Aust.* 2, 724, (1967).
13. Stewart, E. L. and Malfetti, J. L., *Rehabilitation of the Drunken Driver: A Corrective Cure in Phoenix, Arizona for Persons Convicted of Driving under the Influence of Alcohol.* Teachers College Press, Columbia University, New York, 1970.
14. Tonge, J. I., *Post Mortem Blood Alcohol Levels in Road Accident Victims.* National Road Safety Symposium, Dept. of Transport, Canberra, 1972.

The Effect of Rehabilitation on the Driving Behavior of Problem Drinkers

Frank A. Seixas[1,2] and Anna Lee Hopson

This study is a statistical investigation of 782 people (391 subjects and 391 matched controls) to determine if successful treatment of alcoholism improves the driving performance of alcoholic drivers.

The United States Department of Transportation (DOT) has established a large program of countermeasures for alcohol-related automobile crashes. This is justified by many studies which document an over-representation of drinking drivers in crashes and particularly in fatal crashes (9). Because punitive measures, such as revocation of drivers licenses, are generally ignored (5) and other punitive measures have been found ineffective or unworkable (10), the DOT has endorsed programs which attempt to diagnose the alcoholic among driving offenders and subject him to treatment for the alcoholism (3). This rests on the assumption that recovery from alcoholism will result in better driving. It seems obvious that any person, alcoholic or otherwise, who has been drinking, will drive less well than the one who has been sober. However, some critics have postulated that both the drinking of the alcoholic and his poor driving result from a third antecedent (11, 12) and that, in fact, the treatment of alcoholism might be unlikely to decrease the poor driving which results in a crash.

If one could find a population of patients successfully treated for alcoholism and determine their driving behavior before and after this independent treatment, one could determine if such treatment were directly associated with an improvement in driving behavior.

METHOD

Subjects

Alcoholic patients who have undergone successful treatment. Alcoholism is a condition in which there is great variability between clinics and treating facilities in selection of patients, treatment methods and follow-up. The first necessity was to obtain a group on which records of some sort were available over a sufficient period of time. The second requirement was that the individuals had a diagnosis of alcoholism

---

[1] Medical Director, National Council on Alcoholism, 2 Park Ave., New York, New York. 10016.

[2] Supported by Contract # DOT-HS-264-2-479, Department of Transportation, National Highway Traffic Safety Administration, Washington, D.C.

The median age at "return to satisfactory job performance" was 45. To our knowledge, 61 of the 391 experimental subjects and two of the 391 controls left the companies after the six years of observation. Reasons for leaving were as follows: among the experimental group, 22 were discharged, 21 retired or pensioned, five died, four were transferred, two quit, and seven left for 'other' reasons. Among the controls, one person was retired or pensioned and one person died.

Collection, Definition, and Coding for Motor Vehicle Records

Motor vehicle records were obtained from the Motor Vehicle Departments (MVD) in each of the eight states, with the cooperation of the appropriate DOT Regional Administrators.

The following categories of motor-vehicle-law violations were selected for study:

Drunk While Under the Influence of Liquor (DUIL), Drunk While Intoxicated (DWI).
Reckless Driving
Speeding
Collisions: with Property Damage
  with Personal Injury
Driving Without a Valid License
Other: Moving Violations
  Nonmoving Violations.

Of those motor vehicle violations which were selected for this study, two should be explained:

1. Collisions. Collisions were divided into those with property damage and those in which there was personal injury. On the driving records, four states distinguished between these two types of collisions; one state recorded the number of vehicles involved; three states recorded nothing other than "accident". For the four states that did not separate collisions with property damage from those with personal injury, all collisions were recorded as property damage. The assumption was that personal injuries and fatalities were recorded when they occurred.

Although it seems reasonable to assume that collisions resulting in personal injury also entailed property damage, no event was coded as involving *both* personal injury *and* property damage. The index of "total collisions" was made, which is simply the sum of collisions with human and non-human damages.

2. Other. The term "Moving Violation" is used to mean improper or illegal driving behavior. Moving violations include: Failure to stop or yield; failure to obey traffic lights, signs, and signals. Illegal or improper turns. Illegal traffic lane use; driving on wrong side of road; driving the wrong way on a one-way road; driving on shoulder; crossing divider; over center line. Careless or negligent driving. Illegal or improper passing. Following too closely; following a fire apparatus. Miscellaneous moving violations include: No control over car. Fleeing or evading a police officer. In physical control – had been drinking. Failure to dim lights. Improper backing. Wrong stop or turn signal. Failure to give stop or turn signal. Unsafe movement from a parked position.

"Nonmoving Violation" is used to cover those actions which, though infractions of the vehicle codes, are not part of the actual process or act of operating a motor vehicle. Nonmoving violations include: Failure to stop after accident to give aid or information. Failure to report an accident. Illegal transportation of liquor – "open bottle" law. Equipment violations. Unregistered vehicle; failure to notify change of address. Miscellaneous nonmoving violations are: Obstructed vision. Driving without lights. Drunk on highway – walking. Failure to observe unattended vehicle regulations. Driving car which is in an unsafe condition. Improper parking. Exceeding weight limit.

Purging Policies of Motor Vehicle Departments

As a result of the purging policies in five of the eight states, driving records were not always available for the six-year time sequence required by the study design. Thus, some individuals had complete driving data available for the three years pre-treatment and the three years post-treatment; some had data available for only a portion of a year; some had data available for the serious offenses only – DUIL, Reckless Driving, Fatal Collisions, Suspensions and Revocations; and finally, some individuals had no record whatsoever available for a given year.

In order not to lose the cases with incomplete data on their MVD records, statistical adjustments were made. These involved entering the data proportionate to the number of time periods of the six in the complete series for which data were present.

FINDINGS

Comparison of Experimentals in Relation to Controls: Pre-Treatment Versus Post-Treatment

Before treatment, the experimentals had significantly more convictions than the controls for DUIL, Reckless Driving, Other Moving Violations, Total Collisions, Collisions Involving Property Damage, and Driving Without a Valid License. After treatment, there were no significant differences between the experimentals and the controls (Table III).

After the experimentals had been returned to satisfactory job performance, they showed significant reduction in convictions for DUIL, Reckless Driving, Total Collisions and Collisions with Personal Injury relative to the controls.

Comparison of Experimentals: Pre-Treatment and Post-Treatment

The experimental subjects had significantly fewer convictions for DUIL (F-ratio = 13.243: $p < .001$) and for Reckless Driving (F-ratio = 10.618: $p < .01$) after their return to satisfactory job performance than they had before treatment. The average number of their collisions (F-ratio = 5.047: $p < .05$) was also significantly lower after treatment. Although the other differences are not statistically significant, the experimentals had fewer convictions for *all* individual *moving* violations after they had been returned to satisfactory job performance than they had before entry into the employee alcoholism program.

Comparison of Controls: Three Years Before Experimentals Entered Treatment And Three Years After They Returned to Satisfactory Job Performance

No variables intrinsic to the present study affected the driving behavior of the control based on at least roughly comparable foundations. The third requirement was a reasonably objective measure of recovery or improvement.

These requirements seemed to be best met by selecting ‘successfully rehabilitated’ persons in labor-management alcoholism programs. These people are identified as having alcoholism through the objective standard of decrease in job performance, then diagnosed as having alcoholism by alcoholism counsellors and/or industrial physicians. If they accept treatment for alcoholism (agree with diagnosis) they are retained on probation until they are judged to have returned to satisfactory job performance. If they do not accept treatment, they are usually fired from their jobs.

A return to satisfactory job performance is an acceptable standard of recovery, although we recognized that different company policies may be more or less rigorous in applying such a standard. It is likely that recovery is taken to approximate sobriety because of the general design of such programs, although there are sometimes lenient policies for a few ‘slips’ and, indeed, surveillance is small enough in some cases so that some of the alcoholics relapse for varying periods of time before their heavy drinking behavior is again noticed. If such were the case, however, we recognized that this would decrease any pre-post difference in driving infractions and thus tend to make any differences we found more significant.

Suitable controls. With this type of sample, it was possible to obtain controls matched for age (within two years), sex, company, state of residence, and job classification, and to match them by studying their records over the same calendar years as we studied the alcoholic patients.

Driving Behavior

Driving behavior data with the following characteristics were sought:

1. Availability of a large number of people over a varying but long period of time.
2. Objectivity in the sense that the experimental team would not need to grade subtle nuances of history, etc.
3. Potentiality of maintenance of privacy since interviews with individual patients after obtaining their individual consent would have been prohibitive and would have seriously skewed the sample.

Because the National Council on Alcoholism (NCA) has developed labor-management programs in many industries, we were able to enlist the support and participation of several of these companies in performing the study.

The DOT assisted us in obtaining the cooperation of the state motor vehicle departments.

Confidentiality was insured by submitting combined alphabetical lists of names of controls and experimental subjects. When the records were obtained, they were coded, separated, and names deleted.

Nine companies in eight states participated. They represented the following industries: Four manufacturing (two chemical, one automotive, and one electrical), three public utility, one public transportation, one insurance.

From these companies 476 alcoholic subjects were obtained. Of these, 391 (82%) were drivers licensed by the motor vehicle departments in the states where they were employed (Table 1).

TABLE I *Distribution of Original, Interim, and Final Sample of Experimental Subjects by State*

Company	Originally estimated number	Number obtained & submitted to MVD	Number with in-state driver's license
Delaware	150	96	47
Illinois A	200	90	74
Illinois B[a]	2[a]	2[a]	1[a]
Illinois C	67	52	52
Michigan	50	46	44
Minnesota[b]	50	51	49
Montana	23	23	23
N. Dakota	21	21	15
Washington A	40	24	22
New Jersey A	100	19	16
New Jersey B	36	31	30
Washington B	40	21	18
TOTAL	779	476	391

[a] Because only one qualified subject was obtained from this company, the company is combined with Illinois A for statistical purposes.

[b] Although the headquarters of this company is in Minnesota, employees in their Alcoholism Program live (and have driving licenses) in other states as well.

Most (72.9%) of the alcoholic employees in the study had blue-collar jobs in a large corporation; 18.2% had management jobs; 8.9% had office or clerical jobs. The sample is preponderantly male (95.7%). The median age at which the subjects joined the corporation was 27. The median age of the alcoholics' entry into "rehabilitation" was 44 (Table II).

TABLE II *Age of Experimental Subjects at Entry into "Rehabilitation"*

Age	N
Under 20	3
21 – 30	39
31 – 40	130
41 – 50	146
51 – 60	63
Over 61	10
TOTAL	391

TABLE III *Comparison of MVD Records of Experimental and Control Subjects and of the Differences Before and After Treatment*

Violations	Pre-Treatment $\overline{X}^a$	Post-Treatment $\overline{X}$	Before vs. After T-test
DUIL			
Experimental	.035	.008	13.243***
Control	.000	.005	4.035*
RECKLESS DRIVING			
Experimental	.013	.000	10.618**
Control	.000	–	–
OTHER: MOVING VIOLATIONS			
Experimental	.068	.045	1.048
Control	.026	.036	1.643
DRIVING WITHOUT A VALID LICENSE			
Experimental	.019	.006	2.326
Control	.001	.001	–
COLLISIONS – TOTAL			
Experimental	.076	.040	5.047*
Control	.036	.041	.097
COLLISIONS – WITH PROPERTY DAMAGE			
Experimental	.057	.030	3.363
Control	.028	.026	.977
COLLISIONS – WITH PERSONAL INJURY			
Experimental	.018	.010	1.823
Control	.007	.015	3.899*
SPEEDING			
Experimental	.064	.054	.071
Control	.049	.058	.356
OTHER: NON-MOVING VIOLATIONS			
Experimental	.009	.011	.059
Control	.001	.005	1.805

[a] Each mean is the average number of convictions per person *per driver year.* Because of missing data – MVD records were not available for everyone in every year – the N's in each cell vary. The number of people for whom there are MVD records for any given three year period ranges from 267 to 366.

*** $p < .001$
** $p < .01$
* $p < .05$

subjects. There are, however, two significant differences in the conviction rates of the controls in the two three-year intervals – both differences in a negative direction. In the second three-year interval the control subjects were more likely than in the first time period to have convictions for DUIL (F-ratio = 4.035: $p < .05$) and for collisions involving personal injury (F-ratio = 3.899: $p < .05$). The controls also had more convictions for speeding and for Other Moving Violations in the second than they had in the first three-year period, although the difference was not statistically significant.

Changes in Conviction Rates Over Time

In view of the classic description of the progression of alcoholism and recent challenges to the idea of progression, it seemed desirable to look at the convictions year by year.

For three of the infractions – DUIL, collisions involving property damage, (Figures 1 and 2) and Other: Nonmoving Violations for the experimental subjects, the frequency tends to increase from year to year before entry into treatment, peaking during the last year before treatment and to decrease steadily with each year after return to satisfactory job performance. This is in line with the classic theory of the progression of the symptoms of alcoholism.

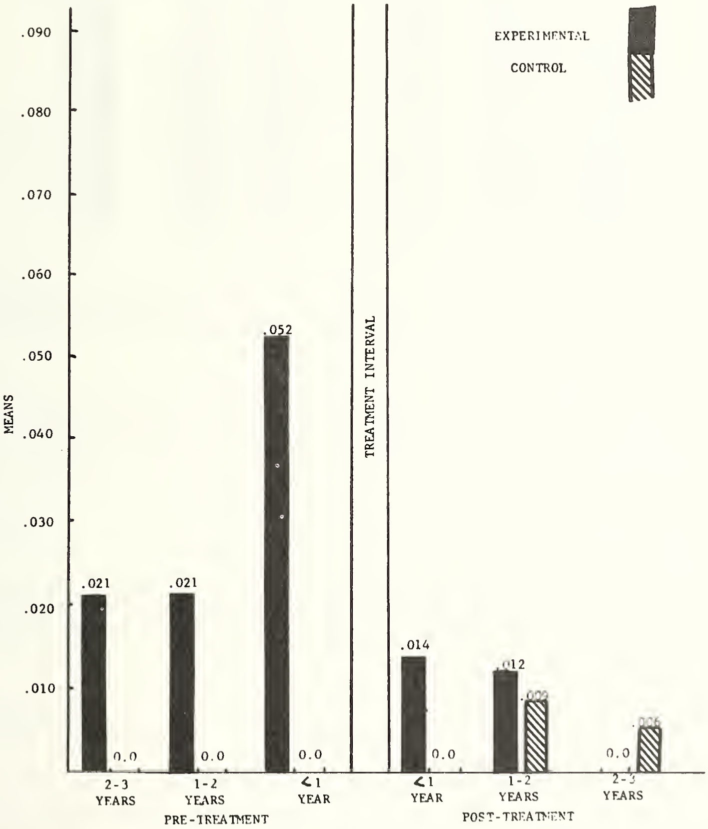


Figure 1 *Mean number of* DUIL *convictions for each of the 3 years Pre-Treatment and each of the 3 years Post-Treatment for experimental and control subjects.*

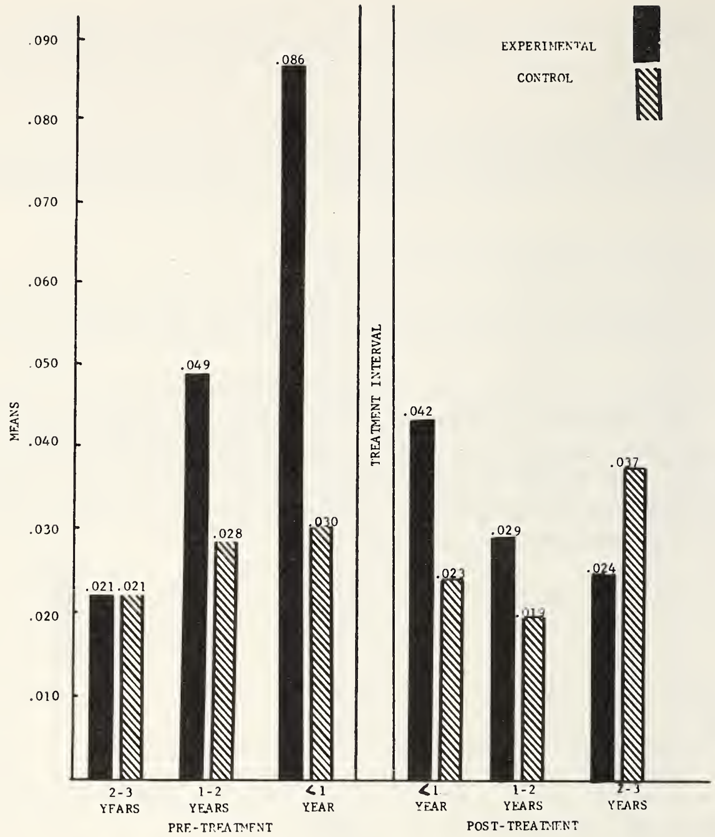


Figure 2 *Mean number of* Collision: Property Damage *convictions for each of the 3 years Pre-Treatment and each of the 3 years Post-Treatment for experimental and control subjects.*

For the other offenses a more variable pattern was found in the individual years. No tests of statistical significance of the differences between individual years were made.

Violations of Controls

"Post-treatment" increases in conviction rates were found among the controls for DUIL, speeding, collisions with personal injury, moving and nonmoving violations. Two possible explanations are advanced for this:

1. There is a possibility that police enforcement and/or mechanical hazards to driving increased during this experimental period. To correct for such variations in specific years was one reason for obtaining control subjects.

2. The presence of DUIL convictions among the controls during the three-year period after the experimentals had returned to satisfactory job performance lead to a justifiable suspicion that some of the controls were alcoholics as yet unidentified by the company alcoholism program.

Comparison of the Distribution of Collisions Among Experimentals and Controls

The distribution of collisions for the experimentals and controls in the two three-year periods covered by this study is presented in Table IV.

TABLE IV *Total Collisions*

Number of Collisions	3 Years Pre-Treatment				3 Years Post-Treatment			
	Experimentals		*Controls*		*Experimentals*		*Controls*	
	N	%	N	%	N	%	N	%
0	211	84.4	230	92.0	273	90.1	271	89.4
1	32	12.8	20	8.0	26	8.6	27	8.9
2	5	2.0	–	–	4	1.3	4	1.3
3	2	0.8	–	–	–	–	1	0.3
N	250		250		303		303	

In conformity with the small expectation of recorded collisions in general (5), it is apparent that only 2.8% of the experimental subjects had as many as two collisions in the three-year period before they entered treatment.

Comparison of Post-Treatment Records of Experimental Pre-Treatment Violators and Non-Violators and Control Pre-Treatment Violators and Non-Violators

The sample of experimental and control subjects was divided into those who had at least one pre-treatment violation and those who had none. More experimentals (40.9%) than controls (27.4%) had pre-treatment violations.

One significant difference was found within the experimental population after treatment. The 'recovered' alcoholics who had had violations before treatment were more likely to have convictions for *speeding* than were the recovered alcoholics who had no violations before their entry into treatment. The controls with previous violations were more likely than those with none to have convictions in the post-treatment period for three categories – DUIL, Collisions with Personal Injury and Collisions with Property Damage.

DISCUSSION

The data indicate a significant improvement in the driving behavior of this alcoholic population after treatment. Another explanation could be entertained: that the change towards fewer motor vehicle violations represents a regression to the mean. There was no way in which the individual subjects could be examined to determine whether driving incidents played a major role in the decreased job performance which led to referral to the alcoholism treatment. This was because of the confidentiality aspects of the study. Experience of other treatment services for drinking-drivers, and discussion with alcoholism counsellors in industry in regard to labor-management alcoholism programs, lead us to suspect that this alternative explanation played only a minor role. Clinical experience with people suffering from alcoholism also corroborates the impression that unless interrupted by external treatment, it is unlikely that the pattern of behavior so firmly established would materially change spontaneously in the majority of subjects. Nevertheless, this is an unanswered question and subject to further research.

The significance of the statistics that became apparent in this study is increased by the fact that driving records were the sole indicator of driving behavior. The inadequacy of driving records is notorious, but each factor which is overlooked in such records is one that could be expected to increase the significance of any differential between the alcoholics and controls. To enumerate these factors:

1. Use of convictions.

a) *Not being caught.* Many incidents of DUIL, Reckless Driving, and other violations simply go undetected by the police. The availability of police varies in jurisdictions and within weeks. Thus, it is possible for a violation to go completely unnoticed (5). 'Good luck' has kept many alcoholics from having any traffic record. Mansell Pattison has estimated that the alcoholics he studied had an average of 100 instances of driving while intoxicated for every DWI arrest (6).

b) *Warnings.* Even when police stop motorists for violations, they often only give warnings. This has been particularly true for driving under the influence.

It has been estimated that a highway patrolman makes an average of two DUIL arrests per year (5). This surprisingly low number can be partially explained by the nuisance value to the officer of going through the procedures involved in making a DUIL arrest, and in the past, the small hope that anything would come of it. One of the salient results of the Phoenix DWI program was the increase in DWI arrests when an understandable, positive program for dealing with them was mounted in the community.

c) *Plea bargaining.* In New York City, DUIL-first offense is a misdemeanor, while DUIL – second offense is a felony. In 1968, there were 3,320 convictions for DUIL – first offense and only five for DUIL – second offense (7).

2. Inadequacy of motor vehicle records.

a) Most MVD records reflect only convictions. A conviction for Reckless Driving may subsume many other unrecorded offenses such as Speeding, Driving over the Center Line, DUIL, Running a Stop Light, or others.

b) MVD records are incomplete even for convictions. We found several driving records clear except for the sole notation "driving while suspended" with no prior suspension or precipitating offense recorded.

c) Policemen sometimes exclude from their reports certain types of collisions, such as those involving only property damage (5).

d) Individuals involved in crashes resulting in property damage will often settle among themselves for fear of having their insurance policies cancelled or perhaps out of fear of having their licenses revoked (5).

e) "Ticket fixing" to avoid an appearance in court or to preserve a "clean" driving record is not uncommon (5).

f) Purging policies decreased completeness of the records. Purging policies of many state MVD's will mean that driving records beyond a three to five year period will be unavailable in the near future. (If anyone wanted to repeat this study at a future date, it is doubtful that replication would be possible because of the destruction of these records.)

3. The nature of the sample.

The alcoholic population in the present study was a stable one. These people spent an average time of 17 years with the same company. Other alcoholics who shift from job to job or who are unemployed may presumably have at least as much trouble on the highway as did the alcoholics reported in this study. (However, an alcoholic population of transient employees could also represent a population not as amenable to treatment.)

4. Elimination of deaths.

A death, by making less than a six-year record possible, would have been eliminated from consideration. It is also possible that deaths would be less likely in this group of alcoholics caught "early" in their disease.

The sum of the above factors represents background for making the statement that the violations here recorded, significant though they are, represent only the tip of the iceberg (Figure 3).

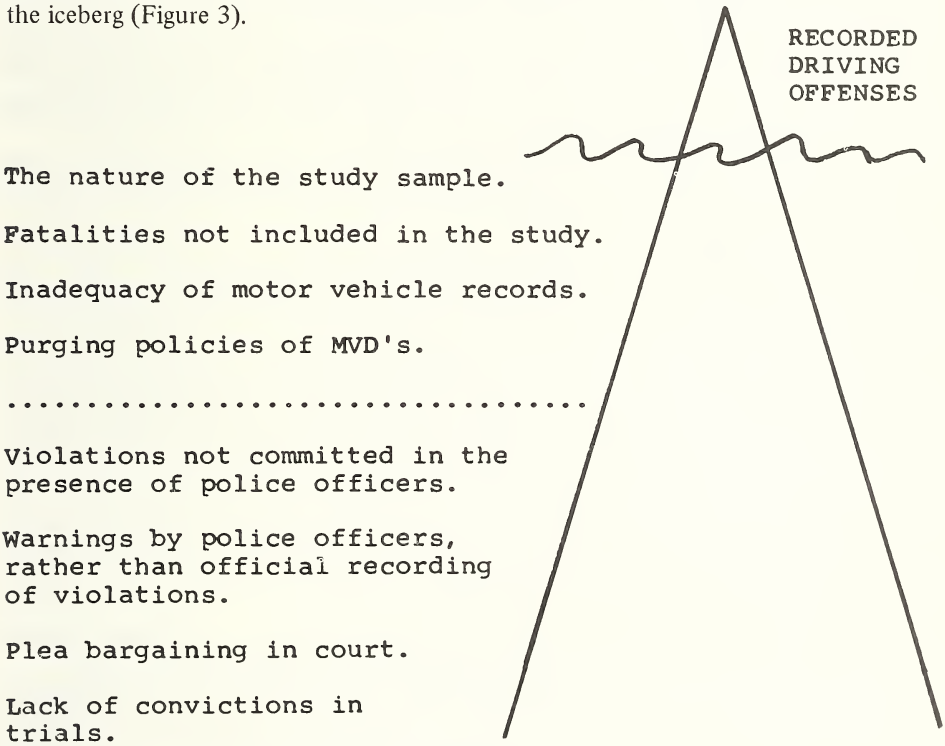

RECORDED DRIVING OFFENSES
The nature of the study sample.
Fatalities not included in the study.
Inadequacy of motor vehicle records.
Purging policies of MVD's.
Violations not committed in the presence of police officers.
Warnings by police officers, rather than official recording of violations.
Plea bargaining in court.
Lack of convictions in trials.

Figure 3 *Recorded driving offences represent only the tip of the iceberg.*

Two Items of Missing Data Which Might Have Confirmed the Findings

The first is the number of miles driven per year. Because we could not interview the individual alcoholics and break the confidentiality of the study, it was impossible to ascertain the number of miles driven per year. This information would have been very helpful. Violations can be expected in direct relationship to amount of exposure. We would have liked to know if the subjects who had violations did, indeed, have the greatest driving exposure. If they did not, there would be a great possibility that, despite the significant decrease in violations post-treatment, the violators formed a separate group who had pre-existing independent factors which induced bad driving with or without sobriety.

One advantage of comparing experimentals to controls was that presumably the driving exposure of both groups would follow approximately the same distribution curve.

A test was made of the hypothesis that the violators did form a separate group. Unfortunately, to do this, we had to compare experimentals with pre-treatment violations to those experimentals without. We thus lost the value of the control group in the effect of driver exposure.

Comparisons between pre-treatment violators and non-violators among the experimental subjects as to "post-treatment" violations showed no significant differences except for *speeding*. This could indicate that: 1) there were, indeed, two groups within the alcoholics: bad drivers and good drivers with or without treatment, or 2) the speeding violation was, for some reason, a poor indicator in the alcoholism – poor driving – crash sequence.

The second item of missing data was the question of speeding, *i.e.*, the number of miles-per-hour over the limit. It will be remembered that only a few states recorded the miles-per-hour over the speed limit on speeding offenses and it was necessary to record only the fact of speeding without modifications.

In our original comparisons of experimentals versus controls, speeding was one of two which did not reach significance.

The speeding violation is the most frequent traffic citation (15). This may reflect not only the fact that almost every driver exceeds the speed limit at times, but also the ease and clarity with which the arresting officer can document his case. Even the construction of automobiles leads to the temptation to exceed the speed limit for everyone, drunk or sober.

Filkins found, among victims of fatal highway accidents, a positive correlation between police estimates of speed and blood alcohol concentrations (BACs). Going from speed estimates of 0-20 miles-per-hour in which 23% had BACs greater than 0.10% to speed estimates of over 80 MPH with 92% of drivers with BACs over 0.10% (4).

Crancer studied victims of fatal crashes and *previous* speeding violations, however, and found no difference between those involved and those not involved. (He did find over-involvement in previous violations – DUIL, hit-and-run, and defective equipment) (2).

Leon Robertson found *no* correlation between speeding and DWI (correlate 0.04) but high correlations between DWI and Reckless Driving (correlate 0.36) (8).

These observations fit nicely into Solomon's findings that drivers travelling at *substantially* higher or lower speeds than the general flow of traffic were more likely to crash than those travelling at the same speed as the general flow (5).

It is suggested by these data that even though speeding is common in fatal crashes with alcohol involvement, speeding *alone* is not sufficiently discriminative to pick out alcoholics from other drivers. It is possible that speeding would be more discriminative if the number of miles-per-hour over the speed limit were known.

We may say then that speeding violations *alone* are neither a predictor of crashes nor of alcoholism and our calculations fail to give convincing support to the hypothesis of a sub-population of bad drivers among the alcoholics. (See Comparison of Post-Treatment Records of Experimental Pre-Treatment Violators and Non-Violators and Control Pre-Treatment Violators and Non-Violators.) Even if there were such a sub-population, the study clearly demonstrates that they would improve in driving behavior under alcoholism treatment.

Progression of the Disease

When the violations were split up into one-year periods, there was a definite trend (best illustrated in Figure 2) to have a progressive increase in violations in the three years preceding treatment, and a progressive decrease thereafter. The trend is consistent with the interpretation that there is, in fact, progression of alcoholism pre-treatment. The progressive decrease in violations following return to satisfactory job performance is consistent with what experience has shown about treatment for alcoholism. The alcoholic, at the beginning of his sobriety, has a backlog of unsatisfactory social and emotional conditions (and, perhaps, legal traffic charges) built up during the years of addictive drinking. These are not all corrected overnight, and the next two years are considered reparative ones, in which the alcoholic builds a new life style. It is expected, and usually seen, that the first two years of recovery are marked by emotional swings and, sometimes, short returns to the use of alcohol and other dislocations. The maturing-out phenomenon is well pictured by the decreasing number of violations after return to the job.

The population studied in this paper is a predominantly middle-aged, working group. Conclusions drawn about this group do not necessarily apply to younger violators. Successful treatment methods would possibly differ in these two groups.

The Effect of Labor-Management Programs

Because employees found to have alcoholism who refused treatment and were fired from the company were not a part of this research study we have no data, nor did we intend any, about the percentage success of such programs. Many companies claim up to 80% recoveries from alcoholism in their programs. An incidental finding of this study is the confirmation of the claim that the return to satisfactory work performance is a measure of improvement through treatment; *i.e.*, confirmed by this measure of an independent behavioral variable – the driving behavior as reflected in the MVD record.

CONCLUSIONS

1. Significant improvement in Total Collisions, DUIL, Reckless Driving, Other Moving Violations, Suspensions and Revocations occurred after "return to satisfactory job performance" following treatment for alcoholism.

2. MVD driving records represent the "tip of the iceberg" as far as revealing the experience of drivers. Thus, more violations than appear on the MVD record can, with confidence, be expected to have occurred.

3. Motor vehicle records at the present time are inadequate and not well-standardized. Purging policies should be reviewed.

4. A sample of alcoholics in industry represents a stable, motivated group of people who may differ from others in treatment needs and treatment outcome.

5. Trends exist in the data which tend to confirm a progression, at least in one phase of the course of problem drinking.

6. Youthful drinking drivers may represent a different population than those found in Labor-Management programs.

7. "Return to satisfactory job performance", when considered in large, seems corroborated as an indicator of improvement in other behavioral attributes.

REFERENCES

1. Coppin, R. S. and Van Oldenbeek, G., *Driving under Suspension and Revocation.* Report number 18, Research and Statistics Section, Division of Administration, California Department of Motor Vehicles, Sacramento, January, 1965.
2. Crancer, A. and Quiring, D. L., *The Chronic Alcoholic as a Motor Vehicle Operator.* Report number 012, Washington State Department of Motor Vehicles, Olympia, May, 1968.
3. Department of Transportation, Highway Safety Bureau, *Alcohol Safety Countermeasures Program.* U.S. Government Printing Office, Washington, D.C., June, 1970.
4. Filkin, L. D., Clark, C. D., Rosenblatt, C. A., Carlson, W. L., Kerlan, M. W. and Manson, H., *Alcohol Abuse and Traffic Safety: A Study of DWI Offenders, Alcoholics and Court Related Treatment Approaches.* HSRI, University of Michigan, Ann Arbor, 1970.
5. Klein, D. and Waller, J., *Causation, Culpability and Deterrence in Highway Crashes.* Department of Transportation Automobile Insurance and Compensation Study, U.S. Government Printing Office, Washington, D.C., July, 1970.
6. Pattison, E. M., Unpublished data. Personal communication.
7. Police Department of the City of New York, *1968 Annual Police Department Report.*
8. Robertson, L., Unpublished data.
9. The Secretary of Transportation, *Alcohol and Highway Safety.* A report to the Congress. Department of Transportation, Washington, D.C., August, 1968.
10. Selzer, M. L. and Weiss, J., Alcoholism and Traffic Fatalities: A Study in Futility, *American Journal of Psychiatry* 122, 762 (1966).
11. Selzer, M. L., Payne, C. E., Westervelt, F. H. and Quinn, J., Automobile Accidents as an Expression of Psychopathology in an Alcoholic Population, *Quarterly Journal of Studies on Alcohol* 28, 505 (1967).
12. Smart, R. G., Are Alcoholics' Accidents Due Solely to Heavy Drinking?, *Journal of Safety Research* 1, 170 (1969).

A Comparison of Changes in Knowledge and Attitude Between Problem Drinkers and Non-Problem Drinkers Following a Reeducation Program

James L. Malfetti and Kenneth J. Simon[1]

For some time it has been recognized that drunken driving is a disproportionately large contributor to highway accidents and fatalities (8, 13). The question now is what can be done to reduce the distressful problem of Driving While Intoxicated (DWI). New York State "DWI Counterattack" is one attempt. This experimental program is a joint effort of the New York State Automobile Association and the Department of Motor Vehicles, made possible by Article 21 of the Vehicle and Traffic Law. Versions of the program are operative in three counties: Erie, Onondaga and Westchester. It is intended to reduce the approximately 3,000 traffic fatalities in New York State each year, about half of which are related to alcohol (12).

THE PROGRAM

"DWI Counterattack" substitutes reeducation and rehabilitation for traditional punitive measures since punishment alone does not seem to work. The program involves only those motorists who have been convicted in Erie, Onondaga and Westchester Counties for alcohol-related violations under Section 1192 of the Vehicle and Traffic Law, or those who have refused the chemical test for alcohol blood level.

Participation is voluntary. Those who elect to take part retain their driving privileges if they attend all sessions of the course held once each week for 5 consecutive weekday evenings in classrooms of the State University College at Buffalo, Onondaga Community College at Syracuse, and Westchester Community College at Valhalla. Each session lasts 2½ hours and is conducted by professional personnel from the affiliated educational institutions.

The aims of the course are to provide information on the consequences of drinking and driving and to consider why people drink and drive, and what countermeasures they can take. The sessions are conducted in a way which encourages a participant to analyze his own drinking habits against the opinions of his peers and his instructors, and to examine ways in which he might modify his behavior. Counselors with special training in alcoholism are present for referrals to community agencies as appropriate. Attendees pay a 30 dollar registration fee, and the course is self-supporting. Tests and inventories are administered at the first and last sessions of the course. The results are used to assist in an evaluation of the course, as well as for program and

---

[1] Box 114, Teachers College, Columbia University, New York, New York.

referral counseling purposes. Full details of course organization and content are contained in an Instructor's Manual (2).

The New York State "DWI Counterattack" program was initiated with class one on November 15, 1971. It was modeled after a similar program in Phoenix (5, 11), and incorporated procedures, teaching aids, and evaluation techniques tested in that program. While "DWI Counterattack" began simultaneously in three counties, this report relates only to the Westchester County Program, which the authors have been monitoring directly, and to classes 10-24 and the 566 graduates of those classes.

Westchester County Program

The ultimate objective of the Westchester course is behavioral modification, specifically reduction or elimination of DWI habits. Although the most generally acceptable way to measure such change is through driving records, such results will not be forthcoming in New York State for some time, and, when they are, will be subject to all the built-in difficulties of such a criterion (4, 14, 15). Meanwhile, the authors have selected knowledge and attitude toward alcohol and driving as measures of change produced by this course. The curriculum is based on three assumptions: (a) drinking is a significant force in traffic accidents; (b) alcohol reduces the skills needed in driving – vision, perception, judgment, motor response; and (c) in a friendly, nonjudicial class setting led by competent educators, violators can be helped to understand the foregoing assumptions and to find ways to improve their own DWI behavior.

It was judged reasonable, therefore, to investigate the extent to which the course was successful in increasing relevant information and improving attitudes, and to assume that persons educated to possess accurate information about the effects of alcohol and the implications of their own drinking and driving behavior would be in a better position to take appropriate countermeasures.

The authors then administered a DWI knowledge inventory and an attitude test in a simple pretest-posttest design to the 360 graduates of the first 9 classes of the Westchester program. Scores on both instruments were significantly ($p < .001$) improved (6).

THE PROBLEM

Meanwhile, numerous studies suggested that of the convicted DWIs sent to rehabilitation such as Westchester "DWI Counterattack," at least a third and perhaps a half were problem drinkers (1, 7). Since alcohol was a pervasive problem for them the question of whether they would profit from a DWI course was raised. The course dealt with only one symptom of their overall problem and therefore efforts relating to DWI knowledge and attitude change might be entirely lost upon them. The investigators were unable to find any studies which have looked into the differential impact of a drunken driver rehabilitative effort on persons with various degrees of drinking problems on the criterion measures of DWI knowledge and attitude change. Specifically, then, the question became: How do problem drinkers and those not so classified compare on DWI knowledge and attitude change after a DWI course?

Definitions

Knowledge is intended to mean possession of factual information relevant to drinking and driving. It is operationally defined as the numerical score on the Drinking and Driving Knowledge Inventory (KI).

Attitude refers specifically to one's feeling about driving after drinking. It is operationally defined as the numerical score on the Drinking and Driving Opinion Survey (OS).

Problem Drinker is the designation given to a person whose consumption of alcoholic beverages exerts a chronic and detrimental influence on his social and/or economic functioning. Operationally, persons with scores on the Alcoholism Indicator (AI) of 5 or more are classified as problem drinkers.

METHODOLOGY

Population

The 637 DWIs assigned to classes 10-24 of the Westchester DWI course which ran from October 2, 1972 to November 5, 1973.

Sample

The 566 DWIs from that population who attended both data collection sessions and thus had prebaseline and postbaseline data available. No data are available on dropouts and "no shows." Also, it is possible that some persons included attended both data collection sessions, but missed some intervening class sessions.

Instruments

Drinking and Driving Knowledge Inventory (KI). This is an objective test comprising 20 multiple-choice items, to measure knowledge of relationships between alcohol and driving. It requires about 10 minutes to administer. The inventory represents a refinement of the original 40 item Drinking and Driving Knowledge Inventory developed by Simon (10) using internal consistency item-analysis techniques on a pool of 152 items. The original inventory had a corrected difficulty level of .54, a mean item discrimination of .56, Kuder-Richardson Formula 20 reliability coefficients of .80, .84, and .85, and apparent content validity.

Using further collected item analysis data from 781 persons, the 40 item inventory was reduced to 20 on the basis of item-test correlation while preserving the content distribution of the test as originally conceived. Thus, the 'best items' from the standpoint of statistical functioning were assembled for the 20 item inventory. Scores on the instrument may range from 0 to 20. Estimates of reliability ranging from .70 to .79 have been made using Kuder-Richardson Formula 20. Content validity is judged to be high. A detailed description of the development of this instrument appears elsewhere (9).

Drinking and Driving Opinion Survey (OS). This is an attitude scale comprising 20 true-false items, designed to measure opinions toward driving after drinking. It requires about 5 minutes to administer. The scale represents a refinement of the original 38 item Drinking and Driving Opinion Survey developed by Simon (10) using equal-appearing interval scaling techniques from a pool of 70 items. The original scale had a mean s value of 5.0, ranging from 1.8 to 8.9, and a mean Q value of 1.5, ranging from

0.6 to 2.4. Reliability estimates of .79 and .84 were obtained using a split-half technique after rank-ordering the items according to item weight, corrected for shortened test length with the Spearman-Brown prophecy formula. Evidence of scale validity was presented using criterion groups.

The 38 item scale was reduced to 20 items using item response pattern data of 792 subjects and maintaining a balance of the scale continuum. Scores on the instrument may range from 2.1 to 8.9. Estimates of scale reliability range from .70 to .90 using the same procedures described above. A detailed description of this instrument appears elsewhere (9).

Behavioral Description Scales (BDS). These scales are composed of 5 items of the multiple-choice type, in which the options represent increasingly positive points along a continuum. The items relate to the individual's 1) willingness to accept responsibility for his DWI arrest; 2) his impression of the fairness of the arrest; 3) feelings about his chances for future arrest; 4) feelings about his chances for changing DWI behavior; and 5) sense of the value of the course in altering his DWI behavior. Only scales 1, 2, and 5 are considered in this report. They provide measures of attitude supplementary to the OS. The other scales were designed to assist in counseling and referral and not as attitude measures. The BDS requires about one minute for administration. The scales were derived informally from the literature on the personality characteristics of alcoholics, and on the objectives of alcoholism therapy programs.

Alcoholism Indicator (AI). This is the instrument used to assign the sample to drinking problem classifications. It is a composite of 9 factors, each contributing a weighted score. From various data collection forms administered to DWIs, the following items and scoring comprise the AI: Have you ever been arrested for other driving offenses involving alcohol? (yes=4 points); Do you think you might have a drinking problem? (yes=2 points); Have you ever sought help? (yes=3 points); Do other members of your family object to your drinking? (yes=2 points); Have you ever lost a job because of drinking? (yes=4 points); 2 points for drinking before noon; 1 point for drinking alone; 1 point for drinking when there is no occasion; 1 point for drinking when there is no reason. The possible range of scores is 0-20. The items were developed by counselors with training and experience in working therapeutically with alcoholics, from approximately 1500 case histories of DWIs, including behavioral records and the results of personal interviews. Items were developed, assembled and weighted by the counselors to reflect the same criteria they use to categorize DWIs by degree of drinking problem: no problem, potential or emerging problem, definite problem. The development procedure has built-in content validity.

Data Collection Procedure

All data in this study were gathered at the data collection sessions which precede and follow each course. Data collection procedures are standardized: printed test batteries are distributed, a brief introduction to the task is made, and persons are directed to complete all forms following the written instructions accompanying the instruments. The test package includes several instruments in addition to those analyzed here. All instruments are scored by a course assistant; BDS, KI, OS, and AI scores are then entered on a coding sheet and keypunched.

Research Paradigm

A three group before-and-after design was created. The sample was divided into three groups as follows: *no drinking problem* (AI=0-1), *potential drinking problem* (AI=2-4), *definite drinking problem* (AI=5+). The three groups were compared for knowledge and attitude change by analyzing postcourse scores while adjusting for precourse dissimilarities.

Analysis of Data

The data were first analyzed descriptively: distribution of AI scores in the sample; mean pre-and-post course scores for each of the three groups computed for BDS, KI, and OS; mean improvement for each AI score computed for BDS, KI, and OS. The data were then treated inferentially: an analysis of covariance on posttest scores treating the pretest scores as covariates; correlations of difference scores (post minus pre scores, yielding an improvement score) of BDS, KI, OS with AI scores.

RESULTS

Of the total sample (N=566), AI scores range from 0 to 16. There are 251 subjects (44.3%) without AI scores.[2] For the 315 subjects with scores, the mean AI is 4.10, with a standard deviation of 3.51 and a standard error of 0.20. The distribution of AI scores is presented in Table I.

TABLE I *Distribution of Scores on the Alcoholism Indicator (AI), N = 566*

AI	f	%	adj. %	cum. adj. %
0	29	5.1	9.2	9.2
1	41	7.2	13.0	22.2
2	77	13.6	24.4	46.7
3	18	3.2	5.7	52.4
4	42	7.4	13.3	65.7
5	24	4.2	7.6	73.3
6	10	1.8	3.2	76.5
7	27	4.8	8.6	85.1
8	9	1.6	2.9	87.9
9	9	1.6	2.9	90.8
10	1	0.2	0.3	91.9
11	17	3.0	5.4	96.5
12	4	0.7	1.3	97.8
13	0	0.0	0.0	97.8
14	0	0.0	0.0	97.8
15	4	0.7	1.3	99.0
16	3	0.5	1.0	100.0
missing	251	44.3	—	—

---

[2] The percentage of missing scores is so high because data were accepted only when answers appeared for all nine AI determinants.

TABLE II *Mean Pretest, Posttest, and Difference Scores, and t Values for Knowledge Inventory (KI), Attitude Scale (OS), and Behavioral Description Scale (BDS) 1, 2, and 5 for Persons without a Drinking Problem (AI=*0-1*), Potential Drinking Problem (AI=2-4), and Problem Drinkers (AI=5+), N=566*

Measure	Drinking Problem	N	Administration	Mean	SD	$\bar{X}$Diff.	SD	t
KI	None	65	Pre	10.49	4.10	4.29	2.84	12.19***
			Post	14.79	3.27			
	Potential	127	Pre	9.43	3.80	4.41	3.45	14.39***
			Post	13.84	3.90			
	Definite	101	Pre	10.42	3.82	3.84	3.02	12.79***
			Post	14.26	3.86			
	Unclassified[a]	233	Pre	9.94	4.05	4.11	3.19	19.65***
			Post	14.05	3.75			
OS	None	56	Pre	5.61	1.21	0.95	1.11	6.42***
			Post	6.56	0.83			
	Potential	121	Pre	5.70	0.93	0.35	1.24	3.07**
			Post	6.04	1.01			
	Definite	95	Pre	5.70	0.92	0.51	1.00	4.93***
			Post	6.21	0.87			
	Unclassified[a]	222	Pre	5.70	1.06	0.40	1.27	4.71***
			Post	6.10	0.96			
BDS 1	None	69	Pre	3.57	1.52	0.62	1.35	3.83**
			Post	4.19	1.20			
	Potential	131	Pre	3.56	1.42	0.52	1.24	4.81***
			Post	4.08	1.26			
	Definite	101	Pre	3.90	1.28	0.40	1.36	2.93**
			Post	4.30	1.14			
	Unclassified[a]	238	Pre	3.78	1.34	0.35	1.30	4.19***
			Post	4.13	1.19			
BDS 2	None	70	Pre	3.10	1.65	0.43	1.57	2.29*
			Post	3.53	1.71			
	Potential	132	Pre	3.40	1.51	0.51	1.45	4.01***
			Post	3.91	1.43			
	Definite	103	Pre	3.57	1.53	0.65	1.53	4.31***
			Post	4.22	1.29			
	Unclassified[a]	236	Pre	3.47	1.55	0.58	1.25	7.13***
			Post	4.05	1.34			
BDS 5	None	68	Pre	3.88	1.03	0.43	1.25	2.81**
			Post	4.31	1.01			
	Potential	130	Pre	4.05	0.99	0.42	1.01	4.69***
			Post	4.47	0.79			
	Definite	100	Pre	4.28	0.75	0.34	0.90	3.77**
			Post	4.62	0.63			
	Unclassified[a]	233	Pre	3.81	1.07	0.64	1.10	8.92***
			Post	4.45	0.79			

* $p<.05$

** $p<.01$

*** $p<.001$

[a] Missing AI data

Mean pre, post and difference scores are presented for all instruments (KI, OS, and BDS 1, 2, and 5) for the three groups classified by relative drinking problem in Table II.

For the *no problem, potential problem*, and *definite problem* drinkers, respectively, mean improvement in KI scores is 4.29, 4.41, and 3.84; and 0.95, 0.35, and 0.51 in OS scores. Improvement in these 6 cases is significant at .001 except OS for the *potential problem* group ($p<.01$). Also, improvement on BDS scores is significant at .001 in all cases except BDS 1 for *no problem* and *definite problem* groups ($p<.01$ for each), BDS 2 for *no problem* group ($p<.05$), and BDS 5 for *no problem* and *definite problem* groups ($p<.01$ for each).

Improvement in KI and OS scores is presented by AI score in Table III. KI improvement ranges from 3.28 (AI=7) to 5.00 (AI=9). All improvement scores are significant at the .01 level or higher, and there does not appear to be a connection between KI improvement and AI score. OS improvement ranges from 0.12 (AI=9) to 1.17 (AI=0). There is no clear connection between OS improvement and AI score.

TABLE III *Mean Improvement in Knowledge Score (KI) and Attitude Score (OS) by Score on Alcoholism Indicator (AI), N=566*

Score	Alcoholism Index	N	$\bar{X}$ Diff.	SD	t
	0	28	4.71	2.93	8.52***
	1	37	3.97	2.76	8.74***
	2	71	4.58	3.40	11.36***
	3	18	4.00	3.25	5.22***
	4	38	4.29	3.71	7.12***
KI	5	24	4.00	2.84	6.89***
	6	9	4.22	2.59	4.90**
	7	25	3.28	4.09	4.01**
	8	9	3.56	2.24	4.76**
	9	8	5.00	1.69	8.37***
	10+	26	3.85	2.75	7.13***
	missing	233	4.11	3.19	19.65***
	0	24	1.17	1.23	4.68***
	1	32	0.78	0.99	4.45***
	2	69	0.32	1.09	2.41*
	3	16	0.65	1.07	2.42*
	4	36	0.27	1.56	1.04
OS	5	23	0.35	0.96	1.74
	6	8	0.99	1.44	1.94
	7	24	0.78	0.94	4.05***
	8	9	0.24	0.65	1.10
	9	8	0.12	1.23	0.26
	10+	23	0.46	0.94	2.35*
	missing	222	0.40	1.27	4.71***

* $p<.05$
** $p<.01$
*** $p<.001$

Improvement scores when AI is 4, 5, 6, 8, and 9 are not significant. For remaining scores, they are significant at the .05 level or higher.

TABLE IV *Mean Improvement in Behavioral Description Scale (BDS) 1, 2, and 5 Scores by Score on Alcoholism Indicator (AI), N=566*

Score	Alcoholism Index	N	$\bar{X}$ Diff.	SD	t
BDS 1	0	29	0.55	1.21	2.45*
	1	40	0.68	1.46	2.93**
	2	73	0.44	1.34	2.79**
	3	17	0.29	0.99	1.23
	4	41	0.76	1.11	4.35***
	5	23	0.39	1.03	1.82
	6	10	–0.20	1.32	–0.48
	7	26	0.39	1.47	1.33
	8	9	1.22	1.48	2.48*
	9	8	0.88	1.55	1.59
	10+	25	0.20	1.35	0.74
	missing	238	0.35	1.30	4.19***
BDS 2	0	29	0.59	1.45	2.17*
	1	41	0.32	1.65	1.23
	2	73	0.43	1.52	2.39*
	3	18	0.33	1.19	1.19
	4	41	0.73	1.45	3.23**
	5	23	0.30	1.66	0.88
	6	10	1.40	1.71	2.59*
	7	26	0.77	1.58	2.48*
	8	9	1.00	1.80	1.66
	9	8	0.62	1.06	1.67
	10+	27	0.44	1.31	1.76
	missing	236	0.58	1.25	7.13***
BDS 5	0	29	0.66	0.86	4.12**
	1	39	0.26	1.46	1.09
	2	73	0.27	1.06	2.21*
	3	18	0.44	1.04	1.81
	4	39	0.67	0.87	4.79***
	5	24	0.63	1.21	2.53*
	6	10	0.20	1.23	0.51
	7	25	0.20	0.71	1.41
	8	9	0.22	0.67	1.00
	9	8	0.00	0.54	0.00
	10+	24	0.42	0.72	2.85**
	missing	233	0.64	1.10	8.92***

*	$p < .05$
**	$p < .01$
***	$p < .001$

Similar data presentation appears for BDS 1, 2, and 5, in Table IV.

Improvement scores for BDS 1 range from -0.20 (AI=6) to 1.22 (AI=8), for BDS 2 from 0.30 (AI=5) to 1.40 (AI=6), and for BDS 5 from 0.00 (AI=9) to 0.67 (AI=4). No trend is apparent from improvement in either BDS 1, 2, or 5 score by the AI score. Most improvement scores are not statistically significant.

Covariance analysis was applied to the three groups to compare their posttest scores while adjusting for pretest dissimilarities. The posttest scores, adjusted posttest scores, as well as the pretest scores, are presented for the three groups for all measures in Table V. Inspecting the adjusted posttest scores, possible trends are noted: for the *no problem, potential problem,* and *problem drinker* groups, respectively, KI scores are 14.48, 14.20, 14.00; BDS 2 scores are 3.67, 3.90, 4.14; BDS 5 scores are 4.36, 4.48, 4.57. That none of these trends is statistically significant can be seen from the results of the covariance analysis summarized in Table VI. The F statistic for the BDS 2 analysis is, however, almost significant ($.05<p<.10$). There is one significant difference found through the analysis, however, and this relates to OS scores. Here are found adjusted posttest scores of 6.58 for the *no problem* group, 6.04 for the *potential problem* group, and 6.21 for the *problem* group. The analysis yields an F of 7.08, significant at .01. The highest scores are found for the *no problem* group, followed by the *definite problem* group and then the *potential problem* group.

TABLE V *Mean Scores on Five Measures (KI, OS, BDS 1, BDS 2, and BDS 5) for No Problem, Potential Problem, and Definite Problem Drinker Groups: Pretest, Unadjusted Posttest, and Posttest Adjusted for Effect of Pretest.*

Measure	Drinking Problem Group	N	Pretest $\bar{X}$	Unadjusted Posttest $\bar{X}$	Adjusted Posttest $\bar{X}$
KI	None	65	10.49	14.79	14.48
	Potential	127	9.43	13.84	14.20
	Definite	101	10.42	14.26	14.00
OS	None	56	5.61	6.56	6.58
	Potential	121	5.70	6.04	6.04
	Definite	95	5.70	6.21	6.21
BDS 1	None	69	3.57	4.19	4.24
	Potential	131	3.56	4.08	4.13
	Definite	101	3.90	4.30	4.20
BDS 2	None	70	3.10	3.53	3.67
	Potential	132	3.40	3.91	3.90
	Definite	103	3.57	4.22	4.14
BDS 5	None	68	3.88	4.31	4.36
	Potential	130	4.05	4.47	4.48
	Definite	100	4.28	4.62	4.57

Scatter plots were created to look at the nature of the relationship between AI and the 5 measures (KI, OS, BDS 1, 2, and 5). Inspection of the scatter plots revealed no systematic relationship of AI with any score.

TABLE VI *Analysis of Covariance Between Three Groups (No Problem, Potential Problem, and Definite Problem Drinker) on Five Measures: Posttest Scores on KI, OS, BDS 1, BDS 2, and BDS 5, using Pretest Scores as Covariates, N=566*

Measure	Source	df	SS	MS	F
KI	Between	2	9.09	4.54	0.56*
	Error	289	2347.10	8.12	
	Total	291	2356.19		
OS	Between	2	11.10	5.55	7.08**
	Error	268	210.03	0.78	
	Total	270	221.13		
BDS 1	Between	2	0.60	0.30	0.28*
	Error	297	323.65	1.09	
	Total	299	324.25		
BDS 2	Between	2	9.35	4.67	2.93*
	Error	301	480.37	1.60	
	Total	303	489.72		
BDS 5	Between	2	1.79	0.90	1.52*
	Error	294	172.90	0.59	
	Total	296	174.69		

* not significant
** $p < .01$

Product moment correlations computed for improvement in each of the 5 measures (KI, OS, BDS 1, 2, and 5) and AI, range in magnitude from .00 to .11, showing a negligible relationship. Thus improvement in any measure is not related to AI score. These findings appear in Table VII.

TABLE VII *Correlation of Improvement Scores (Difference Scores on BDS 1, 2, 5, KI, and OS) with Alcoholism Indicator*

Measure	AI
BDS 1	.00
BDS 2	.04
BDS 5	–.07
KI	–.08
OS	–.11

DISCUSSION

In the present sample, *definite problem* drinkers account for approximately 34.3 per cent, *potential problem* drinkers 43.5 per cent and those without a drinking problem

22.2 per cent. These findings are approximately consistent with earlier cited findings of the problem drinking classifications of DWIs.

The statistical test comparing the three classified drinker groups on improvement on knowledge and attitude measures used analysis of covariance. In the analysis, posttest scores were compared after being adjusted for pretest influence. This powerful technique (3) is appropriate even in instances where statistical adjustment for pretest differences is minimal, such as with the OS, although in such cases its function approaches the analysis of variance.

The descriptive findings are inconclusive. The groups appear to be fairly similar and improvement on KI, OS, and BDS 1, 2, and 5 by AI score seems to be irregular.

The inferential test findings revealed that with covariance analysis, the three groups could not be differentiated on knowledge improvement (F=0.56) but could be on attitude improvement (F=7.08). The major difference here seems to be that the *no problem* group showed significantly more improvement than the *potential problem* group, with adjusted posttest scores of 6.58 and 6.04, respectively. The *definite problem* group came in at 6.21; it seems reasonable to conclude from this that the *no problem* group improves more than the others. A possible explanation for this finding is the fact that for the *definite problem* group (and even the *potential problem* group) to make the type of attitude change sought here would necessitate greater conflict and incompatibility with existing value structure and lifestyle than would be the case for those with no drinking problem. As a result, it may be posited that definite and potential problem drinkers are more resistant to attitude change than non-problem drinkers. If such a speculation is valid, it would seem appropriate to avail these groups of additional and more intensive efforts to deal with the sources of conflicts. However, it should be made clear that the *potential problem* and *definite problem* groups do show significant improvement in attitude, but not to the same extent as the non-problem drinkers. This suggests that while the former groups profited from the DWI course, further affective experiences would be desirable to bring them up to the level of change of the latter group.

Data were checked for linearity and no curvilinear relationship was found between AI and any of the 5 variables of this study. Thus, it seems that the arbitrary grouping into the three drinking classifications by AI has resulted in nonequivalent groups in terms of attitude improvement despite the fact that there is no relationship between AI and OS improvement. However, the fact that there is no systematic relationship between AI and OS improvement suggests that the group differences by OS improvement might not be a stable characteristic of such samples. However, further study would be necessary to support such a speculation.

Another finding of interest relates to BDS 2. Here some tendency, although not significant, was found for *definite problem* drinkers to show greater change in the direction of stating that their DWI arrest was fair. Adjusted posttest scores for *no problem, potential problem,* and *definite problem* groups were 3.67, 3.90, and 4.14, respectively. Here too, however, the finding of no relationship between the variables using a product moment correlation may suggest that any observed difference in BDS 2 improvement by drinker group might be an artifact of arbitrary classification. Further investigation into this area would be desirable because of some of the important implications for rehabilitation of having problem drinkers face the fact that their arrest was fair.

CONCLUSION

Although *no problem* drinkers seemed to show greater OS improvement than *potential problem* and *definite problem* drinkers combined, no relation was found between drinking problem classification (defined by AI) and knowledge and attitude change.

The findings clearly suggest that those DWIs suffering more serious and pervasive problems with alcohol gain significantly in knowledge about DWI and to the same extent as other DWIs. In so far as such change is deemed important, the Westchester County reeduction program is not lost upon them. In addition, the findings suggest that while DWIs with a potential or definite drinking problem improve significantly in attitude, the change is less than that shown for non-problem drinkers. Perhaps the former group should be encouraged to become involved in follow-up experiences planned to produce additional attitudinal and behavioral change.

REFERENCES

1. U.S. Department of Transportation, *Alcohol Safety Action Project, Evaluation of Operations, 1972.* Washington, D.C., Vol. 1, Summary, Page 18.
2. American Automobile Association, *AAA Instructor's Manual for "DWI Counterattack."* The Association, Washington, D.C., 1972.
3. Atiquallah, M., The Robustness of the Covariance Analysis of a One-Way Classification, *Biometrika* 51, 365 (1964).
4. Barmack, Joseph E., Methodological Problems in the Design of Motor Vehicle Accident Research, *American Journal of Public Health* 52, 1866 (1962).
5. *Development and Preliminary Tryout of Evaluation Measures for the Phoenix Driving-While-Intoxicated Reeducation Program.* A report to PPG Industries Foundation. Arizona State University, Tempe, Arizona, 1971.
6. Malfetti, James L. and Simon, Kenneth J. Evaluation of a Program to Rehabilitate Drunken Drivers, *Traffic Quarterly* 28, 49 (1974).
7. Malfetti, James L. and Stewart Ernest I. *Drunken Driving: The Twelve Hours Before Arrest, And What To Do About Them.* A report to PPG Industries Foundation. Teachers College, Columbia University, New York, New York, 1973.
8. National Safety Council. *Accident Facts,* 1973 Edition, pages 40 and 52.
9. Simon, Kenneth J., The Development of Evaluative Instruments for Rehabilitative Programs for Drunken Drivers, *Proceedings of the 18th Annual Conference of the American Association for Automotive Medicine,* 1974. In press.
10. Simon, Kenneth J., *The Effectiveness of the Phoenix DWI (Driving While Intoxicated) Course in Changing Knowledge and Attitude Concerning Driving After Drinking.* Unpublished Doctoral Dissertation. Columbia University, New York, New York, 1972. pp. 91-99.
11. Stewart, Ernest I. and Malfetti, James L. *Rehabilitation of the Drunken Driver: A Corrective Course in Phoenix, Arizona, for Persons Convicted of Driving Under the Influence of Alcohol.* Second Printing. Teachers College Press, New York, New York, 1971.
12. Tofany, Vincent L., New York State's Concern. In *Report on the Governor's Conference on Alcohol Problems,* New York State Department of Mental Hygiene, Albany, New York, 1971. pp. 128-132.
13. Waller, Julian A., Alcohol and Injury, *Safety,* 28 (May-June 1969).
14. Zylman, Richard, Evaluating Driver and Traffic Safety Education Programs: It May Be Tougher Than You Think, *Journal of Traffic Safety Education* **21**, 7 (October 1973).
15. Zylman, Richard and Bacon, Seldon D. Police Records and Accidents Involving Alcohol, *Quarterly Journal of Studies on Alcohol, Suppl.* 4, 178 (1968).

Evaluating the Effectiveness of Reeducation Programs for Convicted Impaired Drivers

Peggy Brown, Paul F. Zelhart[1,2] and Bryce C. Schurr

This paper concerns the simple observation that different evaluation models provide different types of information at different points in the evaluation process. Based upon this observation, we have two primary arguments we wish to discuss. First, we will argue that the evaluative model that has been used to assess Driver Reeducation programs has not been the most appropriate model. Second, we will argue that by examining reeducation programs from the point of view of the social scientist's traditional approach we have limited our understanding of the implications and impact of such programs.

For clarity we should define evaluation. We prefer the definition offered by Stufflebeam *et al.* (7). "...evaluation is the process of delineating, obtaining and providing useful information for judging decision alternatives." The heart of this definition is that evaluation provides information upon which program decisions are made.

THE TRADITIONAL CONCEPTION OF EVALUATION

Larkin (2) has characterized the traditional approach of social scientists to the problem of evaluation of social programs as "evaluation by objectives." Scriven (5) and Stake (6) call it summative evaluation. Ivan Scheier (4) calls it the tooth paste model; using it one asks the question, which group has fewer cavities? Which treatment is most effective? For our present purposes we will call it the *Prove It Model.*

The scientist using this model conceives of a program as having a specific objective that defines its ultimate goal. The *activities* of the program are functions aimed at achieving that objective. In the language of the social science experiment, the *program objective* is the *experimental hypothesis* and the program *activities* are the ex-

---

[1] Applied Psychology Unit, Department of Psychology, University of Alberta, Edmonton T6G 2E1.

[2] This research was partially supported through funds granted by the Ministry of Transport, Ottawa, Canada (The Alberta Impaired Drivers' Program: Final Report on Evaluation Phase I, Proposal for Evaluation Phase II, 1973) and the Summer Temporary Employment Program of the Province of Alberta (T617B – Department of Highways, 1973). In addition, the authors acknowledge the assistance and cooperation of the Alberta Alcohol and Drug Abuse Commission, Alberta Impaired Drivers' Program, Alberta Department of Highways, Driver Review Board, Alberta Department of the Attorney General and Division K of the Royal Canadian Mounted Police in the collection of the data.

perimental treatments. In the terms of driver reeducation programs, the *ultimate objective* is *reduction of highway deaths* due to alcohol intoxication and *driver reeducation* is a *treatment* as are fines, license suspensions and imprisonment. Using the *Prove It Model,* the social scientist attempts to answer the question: Do driver reeducation programs significantly reduce the number of highway deaths due to alcohol intoxication when compared with the other methods of treating convicted impaired drivers?

The *Prove It Model* is the social scientist's Most highly developed tool. Associated with it is a long history of experience and a wide variety of powerful statistical methods. Optimal utilization of the model, however, requires certain conditions. These often include such items as random assignment of subjects to treatments, the existence of a "no treatment" condition, and so forth. In short, the best way to utilize the *Prove It Model* is for the social scientist to be associated with the project when it is being planned so that the necessary conditions for the model can be 'built into' the program. When necessary conditions can be obtained, the advantages are many and well known. Prior planning means efficiency. Less time and money are spent in obtaining data. Because the treatment and evaluation staffs are more likely to share common objectives, reactive effects tend to be somewhat reduced. That is, access to data is freer and there is likely to be less selectivity (bias) in the information offered by the treatment staff to the evaluation staff. The outcome is more likely to be a relatively unambiguous answer to a limited question. That limited question is, should we continue with the treatment program under study or should we terminate the project? It is important to note, however, that the information upon which the decision is based is usually presented at the end of the evaluation period in the form of a final report and that the model does not provide for 'feedback' during the evaluation period.

In terms of driver reeducation programs, the difficulty associated with the application of this model is that the necessary conditions for its application have not occurred in the various programs of which we are aware. Evaluation has been an *ad hoc* affair in the Phoenix and Alberta Programs, and the usual experimental controls have been absent as in the case of most of the Alcohol Safety Action Projects (ASAP).

Despite our reservations about the appropriateness of the *Prove It Model*, what have the results of the evaluation of driver reeducation programs been to date? *Overall it would appear that such programs have a marginal positive effect when recidivism is used as the program objective.* In two of the three major studies of which we are aware (the Phoenix Study by Malfetti and Stewart (1) and the Los Angeles Study by Pollack (3)) although the annual recidivism rates were surprisingly low, they were reduced by a reeducation treatment. In the third major study, the Alberta Impaired Drivers' Program (AIDP) Evaluation Study (9) the impaired drivers convicted in the project area during the first 18 months of the program (June 1970 – December 1971) have been followed up for a minimum period of 24 months and a maximum of 48 months. The recidivism rate for impaired drivers during this period was 20 per cent. And although no reliable reduction in impaired driving recidivism was found to be associated with the treatment program, drivers completing the program subsequently had significantly reduced highway traffic act and criminal code convictions other than impaired driving. Taken together, these results provide justification for continued program development.

Regardless of the outcome of these studies, however, it is obvious that in many communities in Canada, the United States, Europe, Africa and Australia a positive decision to implement impaired driver reeducation programs was made some time ago.

The decision to initiate such programs appears to be based upon the 'experiential' validity of driver reeducation as a method of dealing with the drinking driver problem as much as it is upon the evidence of program effectiveness. There appears to be an impaired driver reeducation movement underway and we doubt that it will be halted by negative finding studies which employ the *Prove It Model.* Moreover, the evaluator employing such a strategy finds himself in an uncomfortable position. If the program is an established and continuing one and has the commitment of the treatment staff, the government, and the public, the question is not one of 'go versus terminate' as the persons involved in the program base their commitment upon their experiences. A discrepancy between the outcome of an evaluation and the beliefs of the persons involved in an established and continuing program will usually be resolved in favor of their belief in the program; and when research findings consistently fail to support the persistent judgment of treatment professionals, as is the case with the impaired driving recidivism studies, there may be reason to call the model into question. Under these conditions a more appropriate question for the evaluation to focus upon is, *how can we improve the program so that its major objectives and sub-objectives are more effectively realized?*

ALTERNATIVE APPROACHES TO EVALUATION

A number of alternative approaches are available to evaluators of social programs. Although these alternative approaches differ somewhat from one another in detail, orientation and scope, they are all major departures from the method that we have labelled the *Prove It Model.* In general these models acknowledge the multiplicity of functions and objectives in a single project or agency and the utilization of information (feedback) for program development is emphasized. Put simply, these models aim at continuous alteration (improvement) of the functions of existing programs rather than unidimensional comparisons between techniques or groups. Larkin (2) presents a systems model of this type. Scriven (5) and Stake (6) call this type of evaluation formative evaluation. We shall call these methods *Improve It Models* of evaluation.

Although more recent, these models already have important methodological techniques associated with them, and exemplary projects can be found in the literature, particularly in the field of educational evaluation, which meet the requirements of scientific rigor. In addition, evaluation by these models has some distinct, if somewhat veiled, advantages. For example, because the purpose of evaluation is to improve the existing program and because there is continuous information exchange between the treatment and evaluation staffs, reactive effects tend to be minimized. We should point out that these models also provide for summative evaluation. If the program functions cannot be improved over time and are judged to be too costly the program can be terminated.

AIDP – Improve It

AIDP is a complex program involving apprehension by police of impaired drivers, conviction and referral by the court, testing, classification, counselling, lecturing to and the referral of participants to treatment centers dealing with alcohol and driving problems. Each of these functional units, the police, the courts, educators and counselors, driver clinics and alcoholism treatment centers, have specific sub-objectives within the overall objectives of the program.

Police may want to increase arrest rates to reduce the number of impaired drivers on the road and may thereby increase the numbers passing through the program. They may try differential detection methods, for example the Alberta Check-Stop Program, and in so doing alter the characteristics of the sample passing through the courts.

The objectives of the judicial system may involve the desire to reduce the number of impaired driving cases or recidivist impaired driving cases appearing before the courts, or to provide better criteria upon which differential sentences may be used to effect the ultimate goals of the program[3].

The treatment staff may wish to increase the number of impaired drivers entering treatment for alcoholism or joining Alcoholics Anonymous. They may also want to alter driving related attitudes and behavior in their clients.

These various sub-objectives may be congruent with or conflict with the overall goals of highway safety. Shifts in procedures in one of the functional units may radically alter the procedures and outcomes of the other functional units or the general outcomes of the program. For instance, such a program might be very successful with young offenders. However, this effect, in terms of the outcome measure of recidivism, might be masked by a change in police apprehension methods which resulted in an increase in the proportion of older offenders entering the program.

A more concrete example can be drawn from AIDP data, where changing the referral criteria or procedures of the AIDP staff may alter the number of persons entering treatment for alcoholism. The proportion of drivers thus referred, who actively enter treatment, may increase or decrease, and the success rate of the alcoholism treatment center may also be affected. During the evaluation period 203 (33% of those attending AIDP) impaired drivers were referred to the Alberta Alcoholism and Drug Abuse Outpatient Clinic. Of this group 38% entered treatment within the six-month period following referral. Forty-two per cent of those referred entered treatment within one year of the referral date. It would appear that a large proportion of the drivers referred to the Outpatient Clinic by the AIDP staff concur with the judgment that they have a drinking problem and seek treatment. Only 10% of the 652 impaired drivers convicted in Edmonton during the evaluation period who were *not* treated by AIDP, entered treatment at a facility operated by the Alberta Alcoholism and Drug Abuse Commission (AADAC). Most of the latter group were referred by Family Social Services and the Adult Probation Branch. It would therefore appear that AIDP is a successful referral agent.

What kind of person was referred to treatment for alcoholism, and were those referred different in important ways from the usual clients seen in the Outpatient Clinic? The primary criterion for referral was driving citations or accidents involving alcohol. When one realizes that only a small percentage of the driving public is ever cited for impaired driving and that the AIDP criterion required an impaired driving conviction plus additional alcohol related traffic incidents, it is obvious that those referred to treatment are not the average drinking drivers. It is the judgment of the AIDP treatment staff that such individuals have profound drinking problems. Indeed, there is some tentative evidence which indicates that AIDP referrals are more difficult cases than the usual outpatient sample. In a separate study by AADAC personnel, counselors have been required to cite their 10 most improved clients. Thus far only one AIDP referral has appeared on this list. If these findings are confirmed by further research, the impact of AIDP referral on the Outpatient Clinic staff might also need to be a part of our evaluation at some future date.

---

[3] Our research has revealed that judges seem to assign persons with somewhat worse driving histories to AIDP.

If driver reeducation programs are here to stay, and they appear to be, evaluation models must be used which make explicit and monitor the multiple objectives and activities of the functional units of these complex programs. Evaluation of such programs in terms of a single terminal criterion, regardless of its apparent appropriateness, is not going to give a full assessment of the impact of reeducation countermeasures.

REFERENCES

1. Crabb, D., Gettys, J. R., Malfetti, J. L. and Stewart, E. I., *Development and Preliminary Tryout Procedure of Evaluative Measures for Phoenix Driving-While-Intoxicated Re-education Programs*: Arizona State University, 1971.
2. Larkin, E. J., Three models of evaluation., *Canadian Psychologist* 15, 89-94, (1974).
3. Pollack, S., *Drinking Driver and Traffic Safety: Final report.* Los Angeles: University of Southern California, Public Systems Research Institute, 1973.
4. Scheier, I. H., Needs of research and volunteer programs. In Zelhart, P. F. and Plummer, J. M. (Eds.), *Institute on Research With Volunteers in Juvenile Delinquency.* Arkansas Rehabilitation Research and Training Center, University of Arkansas, 1970, pp. 7-10.
5. Scriven, M. S., *Methodology of Evaluation.* Rand McNally and Co., Chicago, 1967.
6. Stake, R. E., The countenance of education evaluation. *Teachers College Record* 68, 523-540, (1967).
7. Stufflebeam, D. L., Foley, W. J., Gephart, W. J., Juba, E. G., Hammond, R. L., Merriman, H. O. and Prouus, M. M., *Educational Evaluation and Decision Making.* F. E. Peacock Publishers Inc., Itasca, Illinois, 1971, p. xxv.
8. Zelhart, Paul F. and Plummer, Jack M., *Institute on Research with Volunteers in Juvenile Delinquency*, 1971. Prepared under research Grant No. 16-P-56812/6-06 Social and Rehabilitative Services, Department of Health, Education and Welfare, Edmonton, Alberta.
9. Zelhart, P. F., The Alberta Impaired Drivers Program: Final Report, Phase I. Edmonton: Department of Psychology, University of Alberta, 1973.

Judicial Discretion in Drinking-Driving Cases: An Empirical Study of Influences and Consequences

Murray Blumenthal and H. Laurence Ross[1,2]

A barrier to experimental research on the legal system comes from judges who frequently, and understandably, object to having their judicial discretion replaced in whole or in part by a mechanical schedule called for by a research design. They object on two grounds: first, that they alone under the law are empowered to make certain decisions, such as type or severity of sanction; second, that using a mechanical or pre-set basis for sanction decisions could not duplicate their judicious weighing of relevant factors, thus inevitably leading to inherently unfair decisions and ineffective actions. The counter-argument that this logic applied to medical research would effectively block all progress in the treatment of disease, is generally judged as irrelevant in that – according to many judges – scientific methods cannot be applied to the human behavior since 'no two people are alike'.

This paper reports the results of a recent opportunity to examine empirically the second of the judges' assumptions that judicial decision-making takes more relevant factors into account than a decision dictated by research design, and that judicial decision-making is more effective. The presiding judge of the Denver County Court invited us to compare the effects of fines, conventional probation and rehabilitative probation on the subsequent driving records of drivers found guilty of a first charge of driving under the influence of alcohol (DUI) (1). It was agreed that these sanctions would vary each month for 15 months according to a fixed schedule. We agreed also that the judges were free to vary the quantity of the prescribed penalty to fit the individual case and that in exceptional instances, some other penalty, such as a jail sentence, could be administered. We agreed also that defendants treated in an exceptional manner would be dropped from the comparison of the three major sanction effects. We were assured that such deviations would be infrequent and would be discouraged by the presiding judge of the court. We would have preferred a random assignment schedule. However, this was deemed impractical by the court.

Shortly after the start of the study the presiding judge was replaced as a result of a municipal election. Although the sitting judges agreed to continue to cooperate with the study it soon became apparent that they were departing from the agreed treatment schedule to an extent far beyond the occasional exception we had expected.

---

[1] University of Denver College of Law, Denver Colorado, U.S.A.

[2] The research on which this paper is based was supported by the National Highway Traffic Safety Administration (contract No. DOT-HS-249-2-437).

Despite repeated reminders to the judges, compliance varied from month to month. At the end of the 15-month treatment period, we found that the judges conformed to the schedule 94 per cent of the time during the months when fines were the agreed sanction; 68 per cent of the time when conventional probation was scheduled and only 48 per cent of the time during rehabilitative probation months.

We speculated that since fines were apparently the preferred penalty and since there were more lawyer-represented defendants during the fine months, lawyers had somehow learned of the experiment and had obtained continuances until their clients could appear in court during the fine month. This speculation receives support from our finding that lawyer-represented defendants showed significantly greater delays in the disposition of their charges.

In one sense, the judges' departures are understandable, for a smooth-running court is strongly dependent on the good will of the lawyers practicing in it. The judge who disappoints lawyers in favor of third-party outsiders over a considerable period of time takes a certain risk. However, the benefit of continuing usual practices to the disadvantage of carefully planned research is in the long run counterproductive. The failure to cooperate with research defeats evaluation, criticism, and hence improvement of the system.

Our original intention to compare treatment effects was severely complicated by the judges' deviations. However, we recognized the opportunity to gain insights into the exercise of judicial discretion and its consequences. Thus, in addition to our previous objectives we decided to look at the following:

a) under what conditions did the judges use their discretion to deviate from the scheduled sanction; and b) what were the differences in subsequent driving records of defendants receiving scheduled sanctions compared to those receiving unscheduled sanctions?

CONDITIONS ASSOCIATED WITH JUDICIAL USE OF NON-SCHEDULED SANCTIONS

The first deviation from schedule we looked at involved those defendants sent to jail rather than their receiving one of the three agreed sanctions. We found, first, that no female defendants were sent to jail. Therefore, females were dropped from subsequent comparisons of the jail and non-jail groups. As indicated in Table I, no differences were found between the two groups on age, minority status, previous violations, crash associated with the DUI citation that brought them into the sample, or representation by an attorney. However, differences were found in the respective percentages experiencing crashes or in recorded moving violation points during the two years prior to their entrance into the study. Over 59 per cent of those receiving jail sentences experienced one or more crashes as compared with approximately 41 per cent of the non-jail group ($p < .05$). Similarly, approximately 33 per cent of those sent to jail had 12 or more Colorado violation points as compared with approximately 14 per cent of the non-jail group.

Apparently, the judges' use of a jail sentence was based on relevant criteria of previous crashes and violation points. Results given below show whether or not the use of the sanction had a beneficial effect on defendants' subsequent driving records.

TABLE I *Comparison of Male Defendants Receiving Combined De Facto Sanctions Versus a Jail Sentence*[a]

	Summary of Chi-Square Testing				
Variable	N	d.f.	χ^2	p	Direction of Differences
Age	480	3	3.96	n.s.	–
Minority Status	454	1	0.00	n.s.	–
Previous Crashes	480	2	7.52	<0.05	Defendants with poorer records more likely to receive jail sentence
Previous Violations	480	3	3.26	n.s.	–
Previous Violation Points	480	3	14.22	<0.01	Defendants with poorer records more likely to receive jail sentence
Crash Associated with Criterion Citation	480	2	0.14	n.s.	–
Lawyer Representation	478	1	0.02	n.s.	–

[a] Source: Reference (1) p. 42.

We next compared defendants receiving scheduled sanctions to those receiving unscheduled sanctions (other than jail), first during the Conventional Probation months, then during the Rehabilitative Probation period. We did not make a similar comparison during the Fine months, since so few (approximately six per cent) received unscheduled sanctions instead of a fine.

During the Conventional Probation months, the only significant difference was a lawyer representation as shown in Table II. Over 48 per cent of the represented defendants received a non-scheduled sanction as compared with approximately 11 per cent of those who were not represented by lawyers.

During the Rehabilitative Probation months, lawyers were similarly effective in influencing judicial discretion, with 62 per cent of the represented defendants receiving a non-scheduled sanction as compared with approximately 40 per cent of the non-represented defendants. Females were less likely to receive the scheduled sanction while defendants with poorer previous violation point records were more likely. No differences were found in age, minority status, previous crashes, previous violations or crash associated with the DUI citation that brought the defendant into the study sample (Table III).

TABLE II *Comparison of Defendants Receiving Scheduled Versus Unscheduled sanctions during the Conventional Probation Months*[a]

	Summary of Chi-Square Testing				
Variable	N	d.f.	χ^2	p	Direction of Differences
Age	157	3	3.38	n.s.	–
Sex	156	1	0.13	n.s.	–
Minority Status	145	1	3.69	<0.10	–
Previous Crashes	157	2	1.93	n.s.	–
Previous Violations	157	3	0.56	n.s.	–
Previous Violation Points	157	3	1.30	n.s.	–
Crash Associated with Criterion Citation	157	2	0.63	n.s.	–
Lawyer Representation	156	1	22.66	<0.001	Represented defendants more likely to receive unscheduled fine

[a] Source: Reference (1) p. 38

Thus, except in the use of the jail sanction, our findings support the conclusion that lawyer representation was a major consideration in judicial exercise of discretion in the decision to deviate from a scheduled sanction.

CONSEQUENCES OF JUDICIAL DEVIATION FROM THE SCHEDULED SANCTIONS

To answer the question concerning the effect of the exercise of judicial discretion in deviating from the use of scheduled sanctions, we compared the records of those receiving scheduled and unscheduled sanctions for one year subsequent to the application of the sanction.

We found no significant differences between the subsequent records of defendants given jail and those given non-jail treatment, nor did we find significant differences when we controlled for previous crashes or for previous moving violation points (Table IV).

TABLE III *Comparison of Defendants Receiving Scheduled Versus Unscheduled Sanctions During Rehabilitative Probation Months*[a]

	Summary of Chi-Square Testing				
Variable	N	d.f.	χ^2	p	Direction of Differences
Age	164	3	1.49	n.s.	–
Sex	164	1	5.53	<0.02	Females less likely to receive scheduled sanction
Minority Status	157	1	0.30	n.s.	–
Previous Crashes	164	2	1.27	n.s.	–
Previous Violations	164	3	5.29	<0.20	–
Previous Violation Points	164	3	8.88	<0.05	Defendants with poorer records more likely to receive scheduled sanction
Crash Associated with Criterion Citation	164	2	0.61	n.s.	–
Lawyer Representation	164	1	6.77	<0.01	Represented defendants less likely to receive scheduled sanction

[a] Source: Reference (1) p. 39

TABLE IV *Comparison of Subsequent Crash and Violation Records of Combined De Facto Sanctions Versus a Jail Sentence*[a,b]

	Summary of Chi-Square Testing			
Variable	N	d.f.	χ^2	p
Subsequent Crashes	480	1	0.03	n.s.
Subsequent Violations	480	1	0.36	n.s.
Subsequent Violation Points	480	1	0.07	n.s.
Subsequent DUI Violations	480	1	0.41	n.s.
Time to First Subsequent Incident	480	4	1.09	n.s.

[a] Females dropped from sample [b] Source: Reference (1) p. 26

Comparing the subsequent crash and violation records of defendants receiving scheduled rehabilitative probation to those receiving unscheduled sanctions did not yield any significant differences or identifiable trends (Table V). Comparisons, controlled for sex, previous moving violation points and lawyer representation also uncovered no discernible differences. Similar comparisons of scheduled and unscheduled treatments during the Conventional Probation periods, with and without controls for representation, were equally fruitless (Table VI).

TABLE V *Consequences of Judicial Use of Unscheduled*[a] *Versus the Scheduled Sanction During Rehabilitative Probation Months*[b]

	Summary of Chi-Square Testing			
Variable	N	d.f.	χ^2	p
Subsequent Crashes	164	2	1.12	n.s.
Subsequent Violations	164	2	3.82	<0.20
Subsequent Violation Points	164	2	1.76	n.s.
Subsequent DUI Violations	164	1	0.02	n.s.
Time to First Subsequent Incident	164	4	3.17	n.s.

[a] Fines or Conventional Probation. [b] Source: Reference (1) p. 45

Thus, we were unable to find, within the limits of our study, any benefit of the exercise of judicial discretion in deciding to deviate from a schedule of sanctions dictated by a research design.

SUMMARY AND CONCLUSION

Judges of the Denver, Colorado, County Court agreed to assign penalties of a fine, conventional probation, or rehabilitative probation according to a fixed schedule to 495 drivers convicted of a first offense of driving while intoxicated. However, when judges departed from the schedule in a significant number of cases, the scope of the study was broadened to study the exercise of judicial discretion. Specifically, we set out to find a) under what conditions the judges used their discretion to deviate from the scheduled sanction, and b) what the differences in subsequent driving records of defendants receiving scheduled and those receiving unscheduled sanctions were.

Our results did not consistently support the judicial assertion that judicial

TABLE VI *Consequences of Judicial Use of Unscheduled*[a] *Versus the Scheduled Sanction During Conventional Probation Months*[b]

Variable	Summary of Chi-Square Testing N	d.f.	χ^2	p
Subsequent Crashes	157	2	1.15	n.s.
Subsequent Violations	157	2	1.25	n.s.
Subsequent Violation Points	157	2	0.35	n.s.
Subsequent DUI Violations	157	1	0.03	n.s.
Time to First Subsequent Incident	157	4	1.52	n.s.

[a] Fines.

[b] Source: Reference (1) p. 49.

discretion operates to "match or fit the penalty with the crime". Only when comparing the jail to the non-jail groups did a rational basis for sanction assignment appear, with defendants having poorer previous records being sent to jail. When deviations from scheduled conventional or rehabilitative probation were examined, lawyer representation appeared to be the principal influence, with represented defendants most often receiving a preferred fine. In addition, the results did not show any advantageous differences in driving records for defendants receiving the unscheduled sanctions.

Thus, our study questions one objection to research a legal setting ". . .that using a mechanical or pre-set basis for sanctioning decisions could not duplicate judges weighing of relevant factors, thus inevitably leading to inherently unfair decisions and ineffective actions." The legal basis for objecting to even temporary limitations on judicial discretion for empirical research purposes was not within the scope of this paper and remains in need of continuing critical examination by legal scholars.

The broader question raised by our research concerns the effectiveness of our legal institutions in reaching their assigned goals. At present, such goals are stated ambiguously, without provision for evaluating systematically the extent to which they are reached. We recently proposed (2) a legislative enactment of required goal setting, evaluation and reporting as reproduced in Appendix A. Enactment of such legislation would go far to change the present climate of the courts, with their defensive concern for ritual and possibly out-dated prerogatives, towards an emphasis on outcomes, feedback and institutional change.

APPENDIX A
PROPOSED LEGISLATIVE ENACTMENT (2)

Section 00-00.1 Goal Setting and Reporting

1. The Coordinator of Highway Safety shall develop drinking-driving countermeasure goals at regular intervals with the assistance of those governmental agencies responsible for parts of the state's drinking-driving countermeasure programs and after consultation with relevant citizens' groups.

2. The statement of these goals shall include:

a) planned application of the countermeasures by relevant agencies;

b) the extent to which the programs are intended to modify the public's drinking-driving behavior patterns; and

c) the extent to which the programs are intended to modify the rates and totals of alcohol related traffic violations crashes.

Where possible, these goals shall be stated quantitatively.

3. On or before [a date specified by the Governor] the Coordinator shall make an initial report to the Governor, the [General Assembly], and the public, of the goals developed pursuant to Section (1).

Section 00-00.2 Evaluation and Reporting

1. The Coordinator of Highway Safety shall, to the extent feasible, insure that the major drinking-driving countermeasure programs are susceptible to scientific evaluation and shall provide for such evaluation at regular intervals. Evaluation shall be carried out by the [Coordinator of Highway Safety] or any qualified agency or private organization.

2. The evaluation of these programs shall include at a minimum the extent to which:

a) the programs are applied by the relevant public agencies;

b) the programs are effective in modifying drinking-driving behavior patterns; and

c) the programs are instrumental in modifying the rates and totals of alcohol related traffic violations and crashes.

3. On or before [a date specified by the Governor] the Coordinator shall report annually to the Governor, the [General Assembly], and the public, on the planning, findings and recommendations of the evaluation.

REFERENCES

1. Blumenthal, M. and Ross, H., *Two Experimental Studies of Traffic Law*, Volume I: The Effect of Legal Sanctions on DUI Offenders, U.S. Department of Transportation, Washington D.C., February, 1973.
2. Reese, J. H., Beaney, W. M., Blumenthal, M., Ross, H. L., and Tiffany, L. P., *The Drinking Driver: An Interdisciplinary Approach to the Legal Management of a Social Problem*, U.S. Department of Transportation Washington D.C. July 1, 1973.

The Effect of Lowering the Legal Drinking Age in Ontario on Alcohol-Related Motor Vehicle Accidents

Wolfgang Schmidt[1] and Alexander Kornaczewski

In 1971, the legal drinking age in Ontario was lowered from 21 to 18. There were divergent opinions respecting the desirability and effects of this change. Some felt that the former age restrictions exerted a moderating influence on consumption among the young and reduced the likelihood of the early development of alcohol-related problems. Others pointed to evidence of extensive under-age use prior to the change and argued that a lowering of the legal drinking age would only serve to legalize the status quo. In a preliminary examination of alcohol sales statistics and self-reported data on alcohol consumption, it was learned that the reduction in age limit had led to a substantial rise in the consumption level of the 18 to 20 year age group, which was due primarily to increased drinking in public premises (4). Apparently, young drinkers chose the most visible way to exercise their new legal status. While it seemed certain that the increase in consumption related to the change in the law, it was not known whether harmful effects of alcohol use also increased as a consequence. In the study reported here, the effect of lowering the drinking age on alcohol-related motor vehicle accidents will be examined.

DATA AND ANALYSIS

The data consist of the number of drinking drivers, by age, who have been involved in motor vehicle accidents in Ontario in the years 1967 to 1971 (1). The assessment as to whether the drivers had been drinking or were impaired by alcohol, was obtained from the standard accident reports submitted by the investigating police officers. It should be kept in mind that chemical tests are not usually performed in order to verify these results and therefore these data are not fully satisfactory for present purposes.

The change in legal drinking age affected 18 to 20 year olds while the age groups in the reported data are given in the usual intervals (16-19, 20-24, etc.). Furthermore, the one year reporting periods preclude a separation of the data into distinct before and after periods. The "post-change period" in this analysis comprised the year 1971, which includes 7 months before and 5 months after the change. It should be noted that these shortcomings can only reduce the measurable effect of the change in legal drinking age on alcohol-related accidents in the relevant groups and therefore lend added significance to any differences that are revealed. The analysis had to be restricted to comparisons of the proportional representation of the various age groups in different years to allow for changes from year to year which affected all age groups equally; for example, changes in reporting criteria for accidents involving property damage which occurred in 1970.

---

[1] Alcoholism and Drug Addiction Research Foundation, Toronto, Ontario, Canada.

Any effect of the change in law should become evident in a comparison of the proportion of young drinking drivers involved in accidents in 1970 with the corresponding proportion for 1971. As can be seen, the proportion of 16 to 19 years olds has increased greatly in 1971 (Table I).

TABLE I *Frequencies and Proportions of Drinking Drivers in Accidents by Age, Ontario 1970 and 1971*

	Drinking Drivers in Accidents			
	1970		1971	
Age	N	%	N	%
16-19	1,259	6.949	2,277	10.468
20-24	4,249	23.451	5,179	23.809
25-34	5,123	28.274	5,918	27.207
35-44	3,660	20.200	4,086	18.784
45-54	2,393	13.207	2,746	12.624
55-64	1,128	7.910	1,546	7.107

Applying Marshall's test[2] to these data, a $K\alpha$ value of 9.50 is obtained ($p < 10^{-4}$) which indicates that, in 1971, drinking drivers were significantly younger than in 1970. To test whether this difference was the result of a general shift towards more younger drivers being involved in these accidents, or specifically, the result of increases in the age groups 16 to 19 and 20 to 24 (the groups which contain the ages affected by the change in legal drinking age), goodness of fit tests were applied. Comparison of all

TABLE II *The Percent Contribution of Various Age Groups to Drinking Drivers in Accidents, Ontario 1967-1971.*

Age	1967	1968	1969	1970	1971
16-19	5.546	5.793	6.683	6.949	10.468
20-24	20.538	21.787	23.758	23.451	23.809
25-34	29.185	28.719	28.302	28.274	27.207
35-44	22.743	22.093	20.291	20.200	18.784
45-54	14.274	13.844	13.302	13.207	12.624
55-64	7.715	7.765	7.664	7.910	7.107

[2] $K\alpha$ is the standard normal deviate exceeded with the probability α. The K value of this test refers, not to the differences in the age distributions, but specifically to the question whether, in 1971, the drinking drivers were younger than in 1970 (3).

age groups for the years 1970 to 1971 showed a significant difference in the proportional representation, as might have been expected from the earlier test, ($X_3^2 = 164.2$, $p < .001$). When the 16 to 24 year group was excluded, the differences for the remaining age groups was not significant ($X_3^2 = 3.08$, $p > 0.25$). Accordingly, the 1971 increase was concentrated in the age groups affected by the change in legal drinking age.

To test whether this increase was part of a continuing trend, or specific to the period after the new law came into effect, similar comparisons were made for the years 1967-1968, 1968-1969, and 1969-1970. The data for these years are given in Table II. While there was no statistically significant tendency for drinking drivers involved in accidents in 1970 to be younger than in 1969, the results for the years 1967-1968 and 1968-1969 were each statistically significant. Apparently the 1971 increase in the age groups 16 to 24 was not specific to this year but was part of a long term trend. However, the relative magnitude of the Kα values shown in Table III indicates that this trend became more pronounced in 1971, the year when the drinking age was lowered.

TABLE III *Magnitude of Kα values, 1967-1971*

	1967-1968	1968-1969	1969-1970	1970-1971
Kα	2.66	5.96	0.22	9.50
p	<0.05	<0.01	<0.25	<0.001

This point is also illustrated in Figure 1, which shows the change in per cent of drinking drivers in accidents for various groups, arbitrarily using the 1967 proportions as 100%.

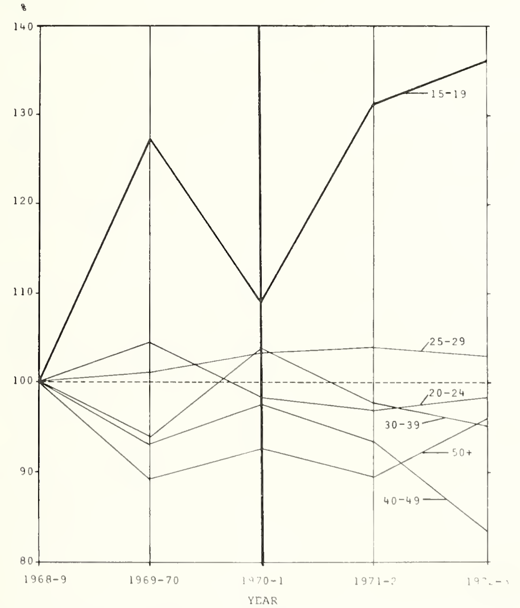


Figure 1 *Change in the proportional representation of various age groups of drivers in fatal accidents, Ontario – 1968-1973. To obtain 12 month periods before and after the inception of the law, the one-year periods span the months August to July.*

Figure 1 also shows that the trend before lowering the drinking age is attributable to both the 16 to 19 and 20 to 24 year age groups, while the 1971 increase is concentrated in the younger group. It is significant that the latter group includes a much larger proportion of drivers directly affected by the change of the law than the 20 to 24 age group.

It seems likely, therefore, that most of the reported increase in 1971 in the proportion of 16 to 19 year old drinking drivers in accidents is the result of lowering the drinking age rather than a continuation of an earlier trend.

The data shown so far refer to drivers who were *reported* to have been drinking when they were involved in accidents. This reported increase may have been due to an alteration in enforcement practice. Because of the publicity about youthful drinking and driving that accompanied the lowering of the age of majority, police may have been more inclined than previously to accuse a young driver of having imbibed. It is, however, also possible that the reported increase constitutes an addition to the total accident involvement of the age group that would not have occurred were it not for the change of the law. This question will be investigated next.

As previously, the method used is the study of statistical trends. The data consist of the number of drivers involved in all accidents by age, type of accident, and month and year of occurrence. Again, the analysis had to be restricted to comparison of the proportional representation of the various age groups before and after the introduction of the new law. This method is feasible because of the relative absence of change in the age distribution of licensed drivers over the period in question.

Figures 2 and 3 show changes in the proportional representation of various age groups of drivers by type of accident. To obtain 12 month periods before and after the inception of the law, the one year periods span the months August to July.

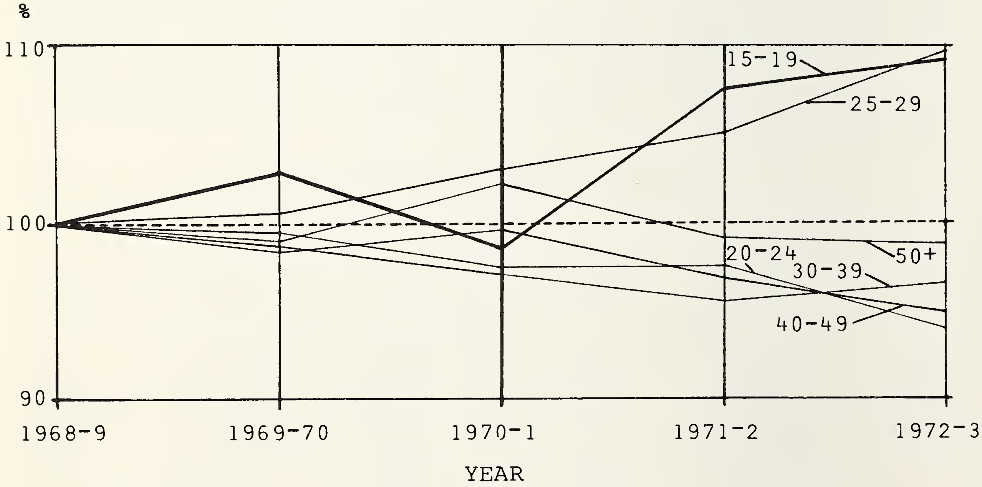


Figure 2 *Change in the proportional representation of various age groups of drivers in personal injury accidents, Ontario – 1968-1973. To obtain 12 month periods before and after the inception of the law, the one-year periods span the months August to July.*

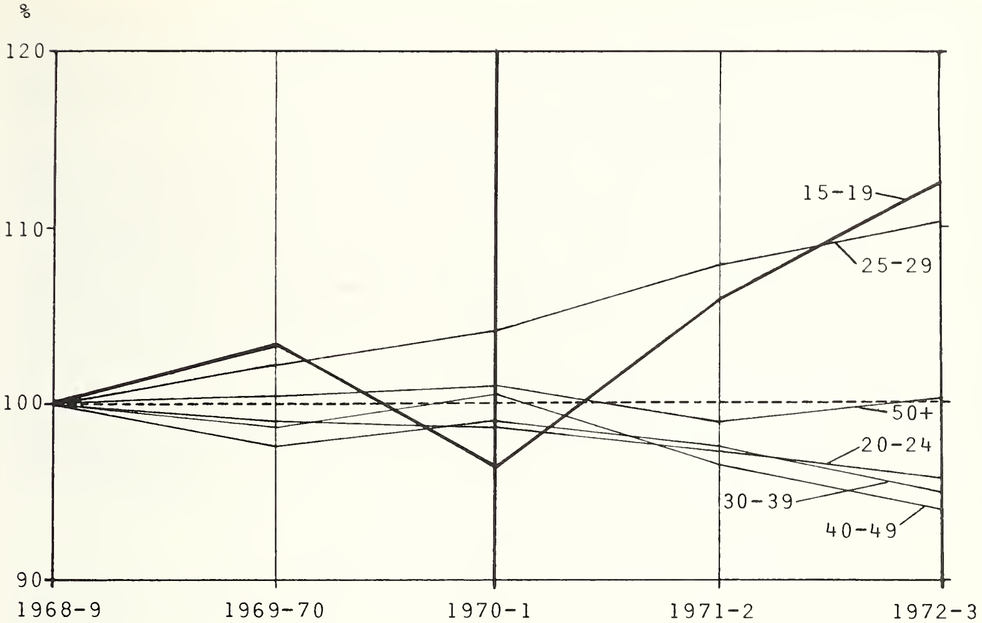


Figure 3 *Change in the proportional representation of various age groups of drivers in property damage accidents, Ontario – 1968-1973. To obtain 12 month periods before and after the inception of the law, the one-year periods span the months August to July.*

Although the proportion of 15 to 19 year olds involved in accidents increased considerably in the 12-month period after the reduction of the drinking age, this increase does not differ significantly from changes that have occurred in other years[3]. Of interest is the continuation of this increase in the 1972 period. It is generally the case, in time series, that changes attributable to chance tend to be followed by observations which are again closer to the trend. Evidently such a regression to the trend line does not occur in our data, but this observation alone does not constitute proof that the new law was responsible for the 1971 increase.

The instability in our data suggests that, in order to be measurable, the effect of the law on accident involvement would have to be considerable. Evidently minor changes in accident rates, as a result of lowering the legal drinking age, would not be discernible from chance fluctuation. This raises the question of how large an increase in accidents could have been expected as a consequence of this new act. In an earlier study (4), it was shown that alcohol consumption among young drinkers increased after the inception of the act and that this increase was almost entirely in the form of on-premise consumption. Although the method used in this study did not permit an exact estimate of the size of this increase, the data indicated that it could not have exceeded 100% and was probably considerably less. If we assume that this increase in consumption has led to a similar increase in driving after drinking and in drinking accident involvement, how would this increase affect the total accident involvement?

The literature provides us with estimates of alcohol involvement in motor vehicle accidents. The most recent and extensive study of this type is the "Grand Rapid

---

[3] The increase in the proportion of 15 to 19 year olds after the inception of the law was significant (e.g. for fatal accidents $X^2 = 13.215$, 1 df, $p < .001$). However, there was also a significant difference, though smaller, among the three pre-change years ($X^2 = 8.755$, 2 df, $p < .05$).

Study" (2). To the extent that the data of this study are applicable in our jurisdiction and in our age group, one would expect that a doubling of the number of drivers with blood alcohol levels over 0.08 per cent would increase the total number of accidents by no more than 13 per cent. Given the extent of variability in our date (Figures 2, 3), an increase of this magnitude would easily be attributable to chance.

The literature also indicates that alcohol involvement in accidents increases with the severity of accidents (2). Thus, a possible effect of the drinking age law would be expected to be most pronounced in fatal accidents. The graph (Figure 1) does support this expectation; the relative increase in the proportions of young drinking drivers in 1971 is largest in this group. However, fatal accidents also involve the smallest numbers and are therefore particularly subject to random year to year fluctuation. For this reason, and because of the shortness of the series, it is not useful to apply conventional methods of statistical analysis.

A measure that is less affected by the instability of these data is a before-after ratio in the number of accident drivers. Since the Act came into effect on July the 28th, the calendar year can be divided into a 7 month period prior to the change and a 5 month period after the change. The before-after ratio consists then in the:

$$\frac{\text{Number of Accident Drivers in Period 1 (Jan. to July)}}{\text{Number of Accident Drivers in Period 2 (Aug. to Dec.)}}$$

TABLE IV *Period 1/Period 2 Ratios of Drivers in Accidents*

	Age	1968	1969	1970	1971	1972
Personal Injury Accidents	16-19	1.13	1.17	1.13	(0.93)	1.17
	20-24	1.18	1.27	1.16	1.07	1.27
	25-29	1.20	1.27	1.10	1.08	1.21
	30-39	1.21	1.27	1.19	1.14	1.24
	40-49	1.20	1.26	1.12	1.15	1.29
	>50	1.14	1.23	1.09	1.11	1.22
Fatal Accidents	16-19	1.13	0.87	1.18	(0.69)	1.00
	20-24	1.02	1.10	1.06	0.94	1.17
	25-29	1.09	1.27	1.03	0.84	1.15
	30-39	1.05	1.29	0.99	1.02	1.20
	40-49	0.87	1.16	0.86	0.82	1.09
	>50	0.80	1.33	0.97	0.82	0.92
Property damage accidents	16-19	1.10	1.14	1.16	(1.03)	1.11
	20-24	1.16	1.26	1.16	1.22	1.23
	25-29	1.19	1.24	1.20	1.26	1.26
	30-39	1.24	1.28	1.20	1.30	1.31
	40-49	1.24	1.26	1.19	1.33	1.29
	>50	1.17	1.23	1.17	1.23	1.19

An increase in accident involvement of young drivers after the inception of the new law would increase the denominator of the ratio in the year of enactment and thus reduce the size of the ratio. A comparison of this ratio with corresponding ratios for other age groups and other years would then reveal whether the inception of the Act affected the accident involvement of young drivers. If the number of accident drivers increased, we would expect the 1971 ratio for 16 to 19 year olds to be the lowest among the various age groups and among the years of observation.

Evidently this expectation is born out by the data: the 1971 ratios for 16 to 19 year olds are the lowest among the ratios in Table IV.

The statistical significance of this decrease in the 1971 ratio of the 16 to 19 year group can be tested as follows:

If the act had resulted in an increase in accident involvement, we would expect the largest decrease in these ratios to have occurred between the years 1970 and 1971 for the 16 to 19 year olds. The probability of this event – assuming it is equally likely to occur in the 4 successive years 1968-1969, 1969-1970, 1970-1971, and 1971-1972 and for all 6 age groups – is:

$$\frac{1}{4} \times \frac{1}{6} = \frac{1}{24} \text{ or } < .05^4$$

SUMMARY AND DISCUSSION

It can be concluded that at least part of the increase in accident involvement of young drivers after the inception of the new Act constitutes an addition to the total accident involvement of the age group, that would not have occurred were it not for the lowering of the legal drinking age. This finding also lends support to the thesis that the increase in the proportion of young accident drivers who reportedly had been drinking was not entirely due to enhanced sensitivity of the police to evidence of drinking.

Thus the data reported here constitute evidence that the relaxation of legal controls on drinking was followed by a rise in consumption and a rise in the damaging effects of drinking. Apparently the former restraints exerted a moderating influence on alcohol use and prevented, at least in some instances, the occurrence of alcohol-related motor vehicle accidents. Whether the relationship between alcohol control measures, the extent of alcohol use, and the magnitude of the drinking driving problem observed among the young, also holds for general populations is not known. The question, however, warrants serious consideration in the light of the worldwide trend towards more liberal drinking laws and the attendant increase in alcohol consumption. Our findings would suggest that, under these conditions, concentration on preventing drinking accidents, without concurrent efforts to change the prevailing drinking practices in society at large, may have only limited effect.

---

[4] Additional probabilities can be calculated: As has been shown, the largest decrease in these ratios occurred among the 16 to 19 year olds between 1970 and 1971. If one takes the difference between this largest decrease and the second largest decrease over these two years, one finds that this difference is greater than comparable differences for other successive years. The combined probabilities of the event described earlier and the event described here are: $\frac{1}{24} \times \frac{1}{6} = \frac{1}{96}$

Similar significant results are obtained when using the proportions Jan. to July and Aug. to Sept. accidents, instead of the ratios employed here.

REFERENCES

1. Annual Reports of the Ministry of Transportation and Communications, Ontario. *Highway Traffic Collisions: Statistics Relating to Motor Vehicle Collisions*, 1967, 1968, 1969, 1970, 1971.
2. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., and Zylman, R., *The Role of the Drinking Driver in Traffic Accidents*, Report of the Department of Police Administration, Indiana University, Bloomington, Indiana, 1964.
3. Marshall, A. W., A Large-Sample Test of the Hypothesis That One of Two Random Variables is Stochastically Larger Than the Other, *J. Amer. Statistical Assoc.* 46, 366-374 (1951).
4. Schmidt, W., *A Note on the Effect of Lowering the Legal Drinking Age on the Consumption of Alcoholic Beverages*, Addiction Research Foundation, Substudy No. 525, Toronto, 1972.

The Impact of the Change in the Drinking Age on the Collision Behaviour of Young Drivers

Paul C. Whitehead,[1,2] John Craig, Nanci Langford,
Carol MacArthur and Bruce Stanton

The current study is designed to assess the impact of the change in the age of majority on the collision behaviour of young drivers in London, Ontario. In July 1971 the legal age for the purchase and consumption of alcoholic beverages was reduced from 21 to 18 in the province of Ontario. By looking at a single community we were able to examine more intensively the impact of the change in the law than was possible through the use of the more extensive, but less focussed data previously available.

Police records of all collisions in London from January 1968 to June 1973 were searched. Data from collisions which involved a driver who at the time was aged 16, 17, 18, 19, 20 or 24 were culled and coded. For the purpose of the current paper the relevant data are the following: age and gender of the driver, year of the collision, time of day, and condition of the driver. By condition is meant the policeman's report that the driver's condition at the time of the collision fitted one of the following categories: "normal", "had been drinking", "ability impaired by alcohol", "ability impaired by drugs", "fatigue", "medical or physical defect" or "other".

Drivers aged 16 and 17 were included in order to examine whether the lowering of the drinking age to 18 had an effect on the younger age groups that were contiguous to the newly legalized drinkers. Twenty-four year olds were included to provide a comparison group of persons who were not directly affected by the change in the law.

Data in our time series include a longer period prior to the change in the law than after (3.5 as compared to 2 yrs.). Thus, where necessary, the data have been standardized to achieve comparability. This means that one can directly compare the incidence of events before the change in the law with those that occurred after the change (Table I).

It has been suggested that in some communities there may have been a sizeable amount of 'clamor' which brought about changes in the enforcement practices of the police. These may have resulted in artificial increases in the rates of alcohol-involved collisions among young drivers when the minimum age for drinking was lowered (2). Our review of newspapers for the time around the change in the law indicates that, at

---

[1] Associate Professor, Department of Sociology, University of Western Ontario, London, Canada, and Research Consultant, Insurance Bureau of Canada.

[2] This is a summary of the paper presented to the Sixth International Conference on Alcohol, Drugs and Traffic Safety. The larger paper will be published in the Quarterly Journal of Studies on Alcohol. This report is part of a larger study supported by the Canada Council of Young Drivers. The assistance of Roberta G. Ferrence in various phases of this project is gratefully acknowledged.

least for London, there is no evidence that pressure was placed on, or felt by, the police to make them more vigilant about an expected increase in drinking and driving among 18 to 20 year-olds. It is unlikely, therefore, that differences reported in the rates of alcohol-involved collisions could be attributed to changes in enforcement practices of the police.

Due to the low rates of alcohol-involved collisions among young females this analysis is based primarily on male drivers.

Other aspects of the analysis that are not presented in this summary, but are contained in the complete paper, address themselves to alternative possibilities that might account for the observed differences. For example the question arose as to whether the observed change is really part of a general pattern of increases among drivers as a whole rather than among young drivers in particular. However, our research results did not support any of the alternative possibilities.

The incidence of total collisions and alcohol-related collisions has been standardized in Table I for male drivers before and after the change. All ages showed an increase in total collisions and alcohol-related collisions.

TABLE I *Incidence (standarized) of Total Collisions and Alcohol-related Collisions for Male Drivers Before and After the Change in the Law*

	Ages 16-17				Age 18				Age 19				Age 20				Ages 16-20				Age 24			
	Alc-Rel		Total		Alc-Rel		Total		Alc-Rel		Total		Alc-Rel		Total		Alc-Rel		Total		Alc-Rel		Total	
	N	STD[a]	N	STD	N	STD	N	STD	N	STD	N	STD	N	STD	N	STD	N	STD	N	STD	N	STD	N	STD
BEFORE LAW	27	16	1304	752	32	18	1055	609	42	24	1193	688	67	39	1303	752	168	97	4855	2801	79	46	1082	624
AFTER LAW	42	42	905	905	79	79	865	865	107	107	940	940	100	100	869	869	383	383	3579	3579	55	55	685	685
PERCENTAGE CHANGE	+162%		+20%		+339%		+42%		+346%		+37%		+156%		+16%		+295%		+28%		+20%		+10%	

[a] Standardized on basis of post-law period.

However, all the results are in a direction that suggests that the major share of change among young drivers may be attributable to the change in the drinking age. Alcohol-related collisions increased 339% among 18 year olds and 346% among 19 year olds while their total number of collisions increased 42% and 37% respectively. Sixteen and seventeen year olds had a 162% increase in alcohol-related collisions and a 20% increase in total collisions. Twenty year olds showed a similar pattern with a 156% increase in alcohol-related collisions and a 16% increase in total collisions. The comparison group of 24 year olds which should not have been as affected by the change in the laws demonstrated a different pattern. Their total collisions showed less of an increase (10%) than the younger age groups, as did their alcohol-related collisions (20%). Specifically, the younger age groups demonstrated an increase in alcohol-related collisions that was 15 times as great as the 24 year olds and an increase in total collisions that was 5 times as great as the 24 year olds. Nevertheless, the standardized increase in the total number of collisions among younger drivers exceeded the increased number of alcohol-related collisions by a margin of 5 to 1 (1463 to 286, respectively).

There is, however, one alternative hypothesis. The increases described thus far may be due in large part to other changes besides the lowering of the drinking age that resulted from the change in age of majority. Such an alternative hypothesis would argue that a change in the age of majority which allowed 18-20 year olds to enter into legal contracts may have made it possible for more individuals to obtain loans and purchase automobiles as they were no longer minors. This in turn provided greater opportunity for driving, thus placing them more 'at risk' than had been the case prior to the change in the law.

In order to test the hypothesis of whether it was the lowering of the drinking age that allowed for an alternation in drinking behaviour or some other aspect of the change in the law that led to greater involvement in collisions, separate analyses of two time periods were conducted and contrasted.

The period 9 p.m. to 3 a.m. is the one that usually contains the greatest proportion of drivers who have also been using alcoholic beverages. Alternatively, the time period 9 a.m. to 3 p.m. is likely to contain very few such drivers. If the non-drinking aspects of the change in the law are to account for the increased collision involvement among young drivers, then the percentage change in total collisions before and after the law should be similar for the 9 a.m. to 3 p.m. time period as for the 9 p.m. to 3 a.m. period. Our data do not support the alternative hypothesis; rather they offer strong support for the initial proposition that the change in the drinking age led to an increase in the collision involvement of young drivers. During the 9 a.m. – 3 p.m. period the incidence of alcohol involvement for all drivers was extremely low in both absolute frequency and as a proportion of all collisions (about 2%), while during the later time period it was about 25%. This then allows us to compare the total collisions during these two time periods, one of which is characterized by high rates of alcohol-involved collisions, the other of which has few alcohol-involved collisions.

After the change in the law, 18 year olds exhibited the largest change (39%) in total collisions during the 9 a.m. – 3 p.m. period which was more than matched by the 58 percentage change during the 9 p.m. – 3 a.m. time period. Nineteen year olds had a 20% increase in the former and a 52% increase in the latter. Twenty year olds experienced a 17% increase in the 9 a.m. – 3 p.m. period and a 31% increase from 9 p.m. – 3 a.m. There was virtually no change (4%) during the early period for 16 and 17 year olds but a substantial 34% change during the late night time period.

TABLE II *Percentage Change in the Standardized Incidence of Collisions following the Change in the Law for Two Time Periods*

	Age					
Time Period	16-17	18	19	20	16-20	24
9 a.m. – 3 p.m.	4	39	20	17	19	18
9 p.m. – 3 a.m.	35	58	52	31	43	1

These patterns contrast sharply with those of 24 year olds who serve as our control for other driving factors which are not contained in either of the competing hypotheses. Twenty-four year olds had an 18% increase in the 9 a.m. – 3 p.m. period and virtually no increase in the 9 p.m. to 3 a.m. time span. That is, they actually demonstrate an opposite pattern from young drivers.

CONCLUSION

The quasi-experimental design used in this study allowed us to control for the major hazards to internal and external validity specified by Campbell and Stanley (1) and allowed us to conclude that the change in the drinking age had an independent effect of increasing the incidence of alcohol-involved collisions and total collisions among young drivers.

Collision behaviour that is attributable to the change in the drinking age had its greatest numerical effect on 18 and 19 year olds, but it had its greatest percentage effect on 16 and 17 year olds.

The non-drinking aspects of the change in the age of majority also appears to have had an effect, though a smaller one. Among 18-20 year olds it is possible that half the increased rate of total collisions may have been due to non-drinking factors while it is difficult to account for the other half of the total increase in any other way. However, among 16 and 17 year olds it appears that the increase in collisions is due almost exclusively to the change in the drinking component of the change in the law.

REFERENCES

1. Campbell, D. T. and Stanley, J. C., *Experimental and Quasi-Experimental Designs for Research.* Rand McNally, Chicago, 1963.
2. Zylman, R., Fatal Crashes Among Michigan Youth Following Reduction of Legal Drinking Age, *Quarterly Journal of Studies on Alcohol* 35, 283 (1974).

The Compulsory Breathalyzer .05% Legislation in Victoria

J.H.W. Birrell[1]

The State of Victoria, Australia's smallest mainland state, had in 1971 a population of 3.5 million people of whom 1.57 million had driving licences to drive some 1.358 million registered motor vehicles. In 1961 there were 773 persons killed and 16,757 injured whilst in 1971 there were 996 killed and 22,067 injured; over this period when deaths increased 28% and injuries increased 37% the number of motor vehicles registered increased more than 100%.

Over the years that I have been associated with the Victoria Police Force (since August 1957), the State has introduced a mix of countermeasures into the road traffic crash field, some perhaps being a little ahead of their time. Thus, compulsory wearing of crash helmets was first introduced in 1961, while compulsory wearing of seat belts became law in 1971. Our compulsory Breathalyzer legislation dates back to 1962.

My appointment as Police Surgeon in 1957 was primarily to take blood alcohols from suspect drunken drivers because very few doctors could be bothered, regarding the procedure as a waste of time. Further, drivers had the right at that time to be tried by judge and jury. This was a futile procedure as illustrated by the fact that in one large city one hundred drunken drivers were tried before the first one was convicted by the jury. The official figure linking alcohol and crashes was some 2 or 3%. This was not verified by my experience at the scene of serious crashes, particularly at night, where, if the driver was not frankly intoxicated, the pedestrian had serious buttock lacerations from the broken bottle in his hip pocket.

The taking of blood alcohols was regularized in 1958, but on a voluntary basis. The blood alcohol level found on analysis was considered with other evidence. The uselessness of the so-called sobriety tests in diagnosing driving impairment soon became obvious because police only picked up and proceeded against those who were frankly and obviously drunk.

In 1961, as a result of Dr. Norman McCallum's efforts, the Borkenstein Breathalyzer was quietly introduced in place of blood alcohols, again on a voluntary basis, but backed by a most competent scientific laboratory and after careful selection and training of police technicians. Experience has shown that this backing is vital to any breath test program.

In 1962, partly as a result of a political accident, the Breathalyzer test was made 'compulsory'. Refusal to take the test was met by a small fine at first and then by cancellation of the driver's licence for 3 months. Today refusal is a serious offence involving cancellation for 12 months, resulting in the present low refusal rate of about 2%.

---

[1] Victoria Police Surgeon, Victoria Police Department, Melbourne, Australia.

In the early sixties the breath test result was only considered in conjunction with all the other evidence before the court. At that stage, some 2,000 arrests were being made per year, the courts virtually still demanding drunkenness as evidence of impairment of driving.

In 1963-64 however, we were fortunate in Victoria to have a Royal Commission study and report on the sale and social consequences of the consumption of liquor. This was conducted thoroughly and efficiently by the late Sir Phillip Phillips Q.C. (14). The report is now a sought after source document.

Phillips (14) made two important recommendations affecting road traffic behaviour. He recommended (a) a change in the closing time of licensed premises from 6 p.m. to 10 p.m. and (b) that a new offence be created involving driving a car with a blood alcohol level greater than .05%. Many of us thought .05% a little low from the political point of view but Sir Phillip was quite adamant that it was the correct level and that the politicians would buy it.

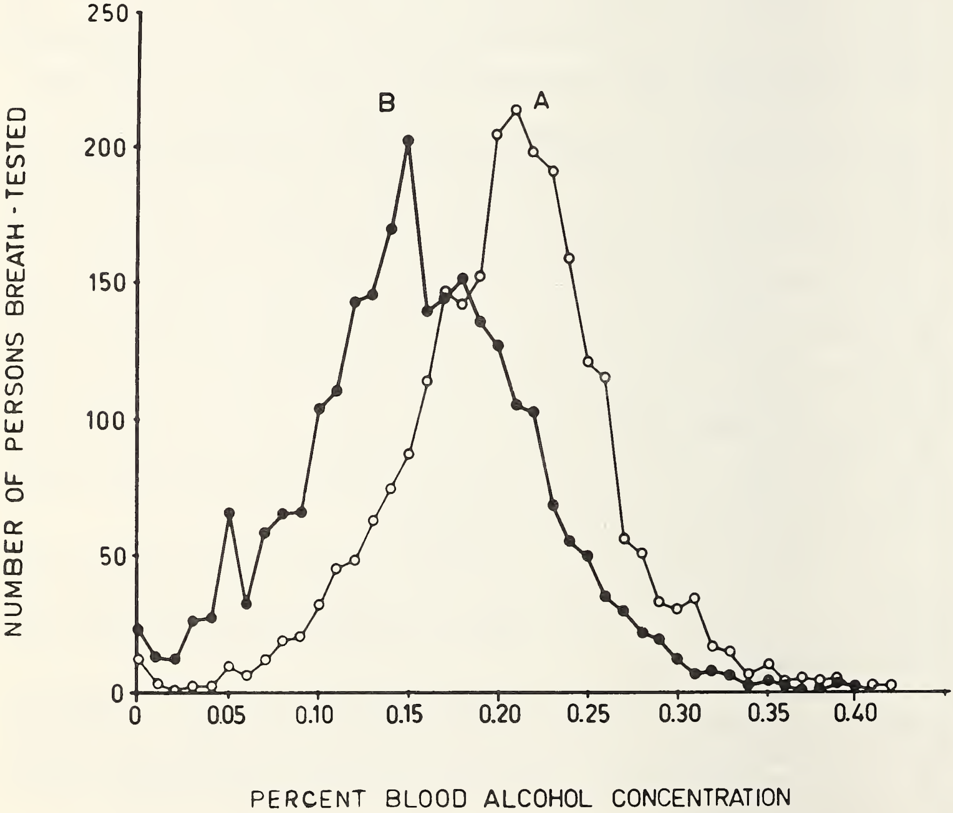


Figure 1 *Change in blood alcohol levels produced by the introduction of the 0.05% legislation.*
A: Before 1966.
B: After 1966.
Source: Reference (12). Reproduced with the permission of Dr. N.E.W. McCullum and the Editor of The Medical Journal of Australia.

The introduction of the .05% legislation has been, in fact, a master stroke. In one move it has done away with defining drunkenness, degrees of intoxication and impairment. If a level of over .05% is found in a driver within 2 hours of his apprehension then he is prima facie guilty.

To the scientific purist it was perhaps disappointing that both recommendations, *i.e.*, the change in licensing hours from 6 p.m. to 10 p.m. and the creation of a new offence, .05% legislation, became law simultaneously in February 1966. This negated any scientific assessment of the effect of the introduction of the .05% law. The .05% legislation received publicity but was not accorded any public educational program by the authorities.

In the event, there was a quite remarkable shift in the times of occurrence of serious traffic accidents but virtually no change in the total number of crashes and deaths. The arrest time pattern also changed, while the blood alcohol levels of those being apprehended began to include many between 0.1% and 0.2% (Figure 1). In fact, the numbers apprehended and breath tested increased from 1,218 in 1961 to 4,178 in 1967 and rose to 10,793 in 1972, which are the last figures available.

Police are continually being surprised, and educated, by the high levels found in such drivers in the presence of few signs or minor evidence of intoxication.

Police in Australia have been accused of being incompetent to operate the Breathalyzer instrument because they are biased. The available evidence would indicate that they are biased, but in favour of the suspect. We found in Victoria a "sore thumb" effect in the distribution curve at .045%. Therefore we predicted that with a .08% offence level there would be a "sore thumb" at .075% (Figure 2). This in fact proved to be the case when New South Wales figures became available. In New South Wales the suspect had the right to demand a blood test subsequently and often unknown to the Breathalyzer operator. Even allowing for a 3 or 4 hour delay before the blood was taken, the breath tests in the field agreed remarkably with the subsequent blood tests.

I think it fair to say that we are more than satisfied with police operation of the Breathalyzer. Moreover, they have voluntarily undertaken much valuable educational work with the instruments.

Since 1966 there have been three offences involving alcohol and driving (a) driving a car with a blood alcohol level greater than .05%, (b) drunken driving, or driving under the influence to such an extent as to a incapable of having proper control of a motor vehicle and (c) drunk in charge, where the car is not in motion, but there are grounds for suspicion that it is about to be driven.

Whether the charge should be BAC in excess of .05%, or whether it should be drunken driving plus BAC in excess of .05%, is left to the discretion of the police. However, since the .05% charge is single and straightforward, taking relatively little time, this is the preferred charge and the number of persons charged with drunken driving is consequently rapidly decreasing.

The most recent legislative action in the field has been the passage of legislation for blood testing all traffic crash victims – drivers, cyclists, passengers or pedestrians – admitted to hospital. The legislation was only proclaimed a few months ago. It is full of holes and teething problems but will no doubt settle down. As one would expect, the results have been horrifying. The first batches analyzed included several with levels of over .3%. The highest breath test so far recorded in a driver has been .47%.

There is no doubt that the advent of the Breathalyzer and the .05% legislation has remarkably and rapidly widened our knowledge of drinking and crashing drivers. Thus, John Lane (9) has recently compared the distribution of alcohol levels in 3

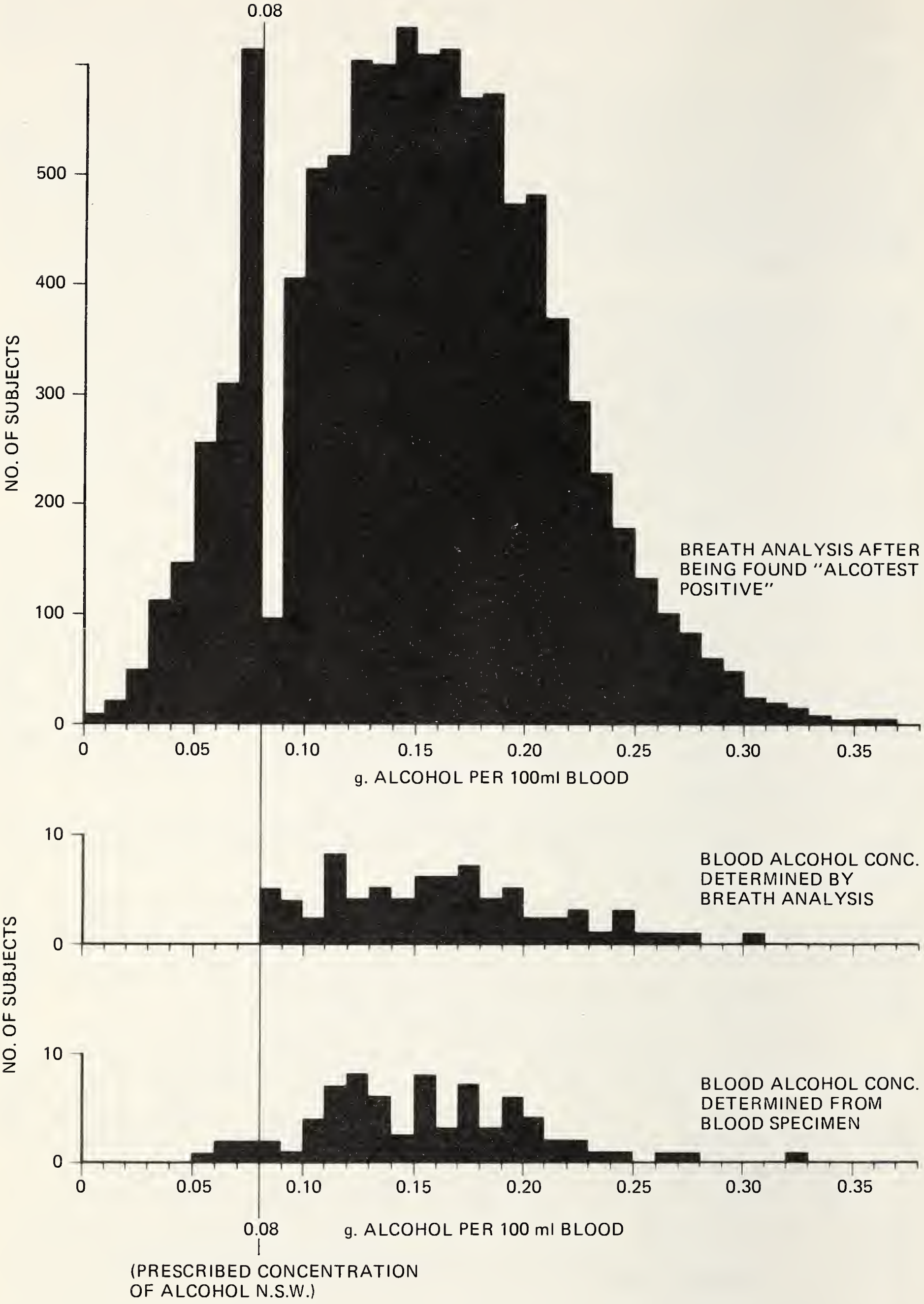


Figure 2 *Concordance between BACs determined by blood specimens and breath analysis. Results of breathalizers in New South Wales, Australia, showing a sore thumb effect at 0.075%.*
Source: Reference (17). Reproduced with the permission of Dr. R. Simson.

groups of drivers. First, fatally injured drivers, second, injured drivers taken to hospital and third, drivers who have been apprehended at the scene and are uninjured when breathalyzed (Figure 3). All three groups showed a similar distribution curve so that it is reasonable to assume they are different samples of the same population and it is a matter of chance into which group they fall.

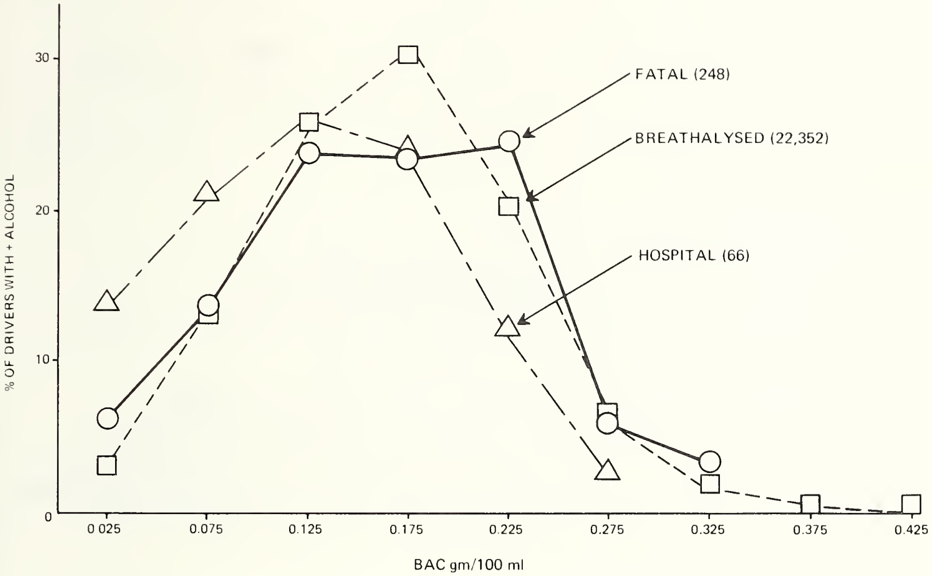


Figure 3 *Comparison of BACs of fatally injured, hospitalized and breathalized drivers. Source: Reference (9). Reproduced with the permission of Dr. J. Lane.*

The overall mean value of the drinking driver in hospital, mortuary, or apprehended at the scene is around .15%, a percentage which requires the consumption of large, if not pathological, amounts of liquor. For example, such a BAC level may be reached by consumption of 15 ozs of spirits in one hour (3). This figure may be put into perspective by the fact that breath analysis of 250 drunk and disorderly cases within 2 hours of arrest produced an average of just under .2% (Figure 4).

Anne Raymond (15) has investigated the drinking driver in greater detail, comparing a 10% sample of breathalyzed Victorian drivers with a control sample of male drivers. (It should be noted that the road crash problem and certainly the drinking driver problem is almost entirely a male problem.) She found that the breathalyzed drivers had more traffic convictions of any kind than the controls, 3 times as many traffic convictions for offences other than speeding, 10 times as many serious traffic offences, 3 times as many licence withdrawals, 10 times as many drink-driving convictions and 10 times as many convictions for unlicensed driving. Almost 40% of the breathalyzed drivers had criminal records for offences other than on the roads.

Eda Ots (13) recently followed up 300 drivers who had been convicted of drink-driving offences for some 2½ years. Forty per cent of the total 300 drivers had been reconvicted of either criminal or driving offences during the follow-up period and nearly half the subsequent offences were drink-driving offences. Ten per cent were

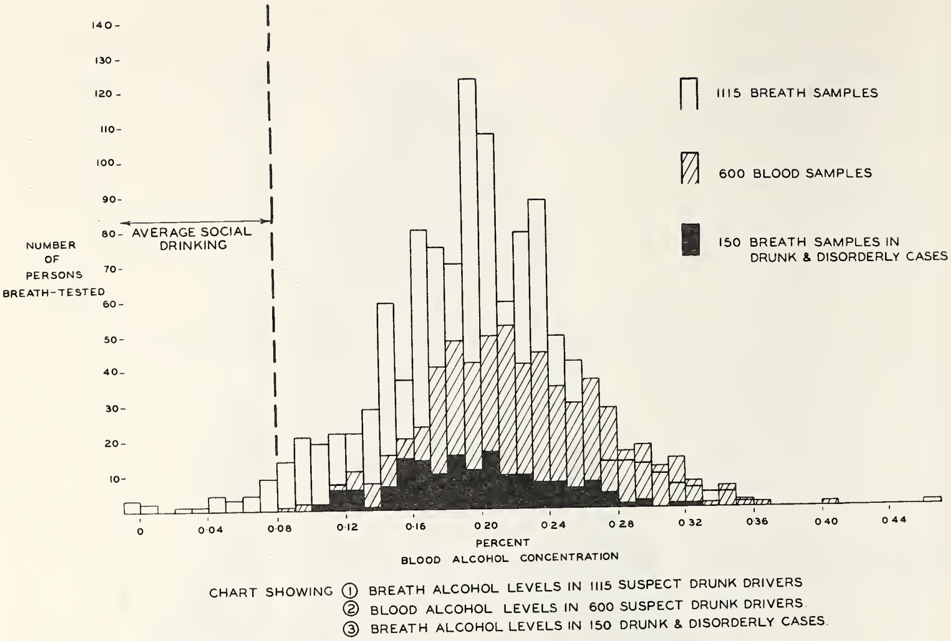


Figure 4 *Comparison of breath alcohol levels in suspect drunk drivers, blood alcohol levels in suspect drunk drivers and breath alcohol levels in drunk and disorderly cases.*

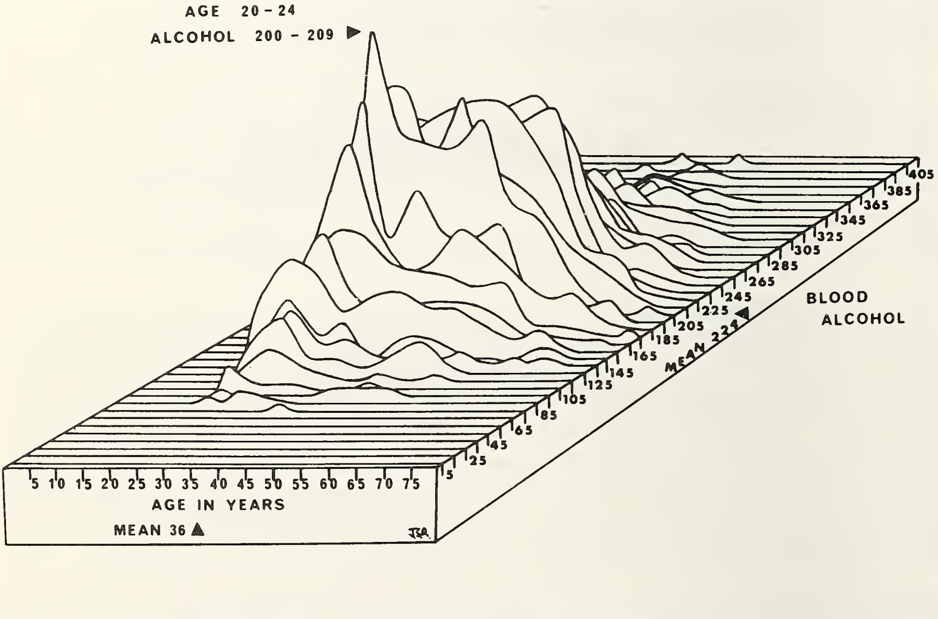


Figure 5 *Age and BAC distributions for 2505 Melbourne DUI cases.*
Source: Reference (3). Reproduced with the permission of Medicine, Science and the Law.

detected driving while disqualified and one third were found to have one or more traffic crashes involving personal injury subsequent to their initial conviction.

In 1967 I assessed a group of 25 dead car drivers who had collided head-on with Melbourne's streetcars. Forty per cent had criminal records and one third had prior trouble with alcohol. One even had a bail bond in his pocket for a drunk arrest the night before. Moreover, the passengers of killed drivers have been found to have blood alcohol levels corresponding to those of the driver (4).

All work now indicts the young 18-25 year old males drinking heavily at weekends as perhaps the core of the problem. However, they are by no means the whole problem. Thus distributions of BAC invariably have two peaks, one in the 18-25 year range and another around 45 years, which indicate significantly higher alcohol levels (Figures 5, 6 and 7).

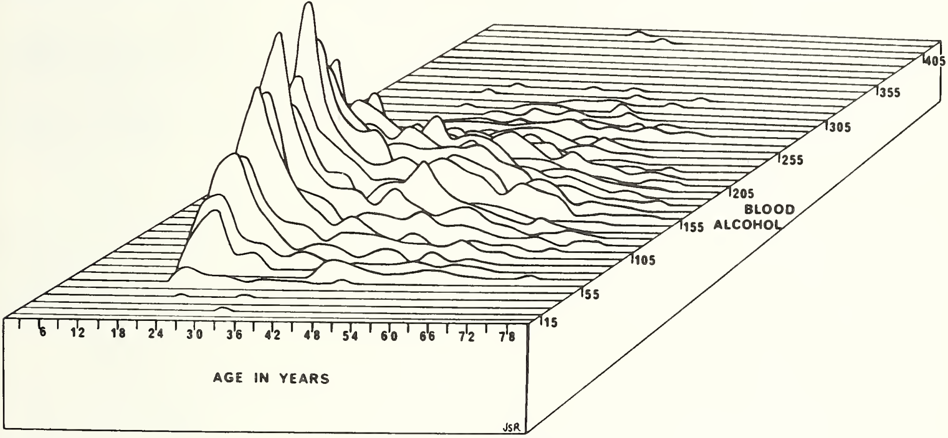


Figure 6 *Age and BAC distributions for 6045 Melbourne cases exceeding 0.05%.*
Source: Reference (3). Reproduced with permission of Medicine, Science and the Law.

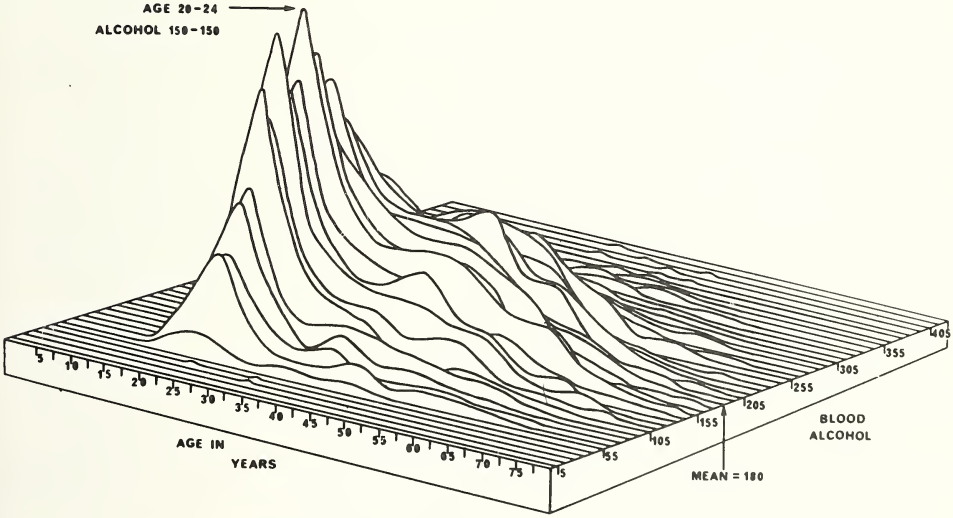


Figure 7 *Age and BAC distributions for 8550 Melbourne drinking drivers.*
Source: Reference (3). Reproduced with the permission of Medicine, Science and the Law.

The whole field of alcohol, and alcohol and driving, is bedevilled by folk-lore, one of the common pieces being that everybody drinks and drives. The Grand Rapids survey (6) was the first important study which indicated that most people did not drink and drive.

Research in the area of drinking and driving habits was also recently conducted in the city of Canberra by John Duncan (8). Two experiments each involving 3,500 interviews and breath tests were conducted from November 1971 to February 1972. The experiments measures time units of driving over the hours 10 a.m. to 2 a.m. the next morning.

Overall, 89% of driving was done without alcohol. Five per cent of the drivers were above .08%, including roughly 3% unknowns and .5% refusals. However, even between 10 p.m. and 2 a.m. 75% of drivers tested were without alcohol, another 15% being under .08%, 4.2% above .08%, 4.7% unknown and .12% refusing.

Folk-lore often sustains people in the idea that drinking implies getting drunk. However, this too does not square with the facts. For example, at one free dinner where there was a great deal of alcohol available and no speeches, it was announced five minutes before the end of the dinner that Breathalyzers were available for the

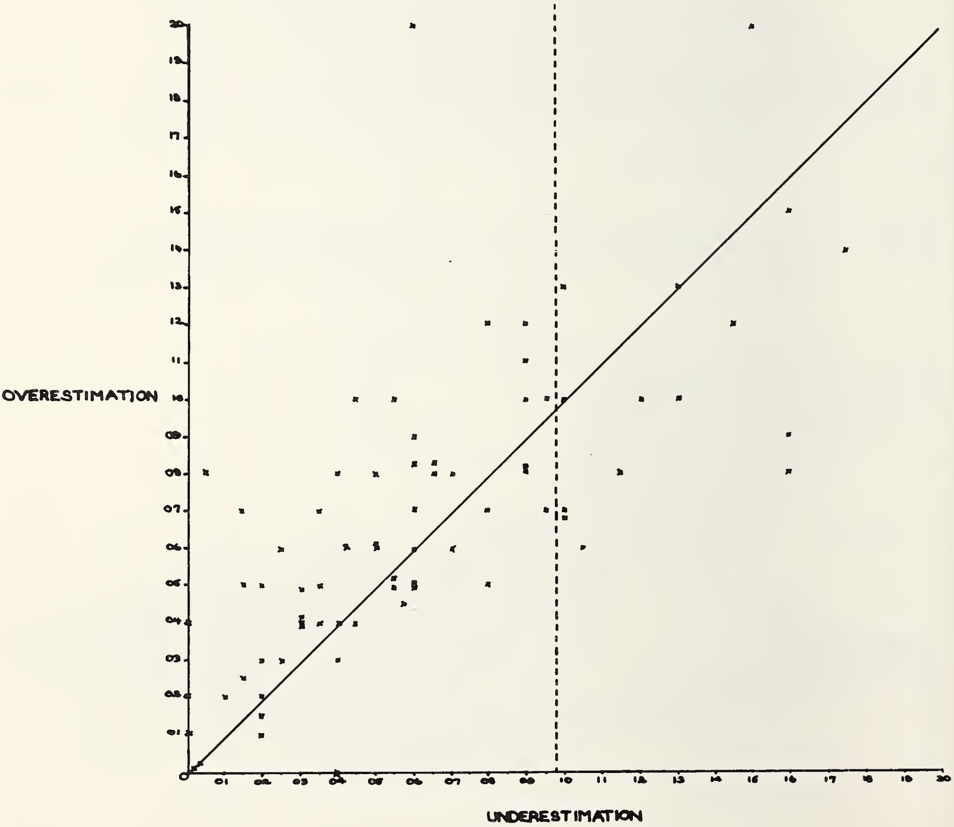


Figure 8 *Graph illustrating that drinkers with a BAC level above 0.1% underestimate their condition and BAC level.*
Source: Reference (16). Reproduced with the permission of Dr. A. Raymond.

participants to check their alcohol levels (16). All the participants were staying at the function venue and only 2 women were present. Some 82 breath tests were carried out. Seventy three per cent were still under .08%, only 6% getting to above .15%. Of those tested, 74 estimated their alcohol levels, 35 being within .015% of the actual level. However, while of those under .1%, overestimation of their level was the rule; of those over .1%, underestimation was the rule – often alarmingly so (Figure 8).

Overall assessment of the mass of material which has emerged with use of the Breathalyzer shows that the drinking driver is usually a deviant. Generally, the best guide to his future performance is his past performance. Further, it has become obvious that he is not a light or social drinker but commonly drinks to excess regardless of the consequences. Indeed, a number of such drivers qualify as alcoholics by any definition. There would be few today who would argue against the proposition that while some of these drivers with high alcohol levels may not be alcoholics in the full sense of the term, arrest for a drunk driving offence is a strong indication that the person is predisposed to alcoholism.

What then has been the effect of Victoria's Breathalyzer legislation on road traffic crashes? Any real attempt to assess the effectiveness of the .05% legislation as a deterrent was, as I have pointed out, unfortunately negated by the concurrent change in closing hours of licensed premises.

There is anecdotal evidence of thoughtful people changing their habits. I think the percentage of drinking drivers with criminal records is rising, but overall there was no real change in our traffic crash figures until the wearing of seat belts became compulsory. This is not to decry the legislation, because without it we should still be blundering along in the dark.

There are still some magistrates and lawyers equating impairment of driving to drunkenness, saying that if a driver has a level of .25% and is still on his feet the chemical test must be wrong. However, there are many experiments in the literature, (more than sufficient), documenting the fact that measurable deterioration of driving performance is present before any clinical signs of intoxication appear.

Doug Lucas (10) and the late Ward Smith's classic experiment in the CTV film "Point Zero Eight", first showed the existence of driving deterioration before clinical signs of intoxication. Real speed was used for the first time in the test. Professor Syd Lovibond (11) at the University of New South Wales has further documented this in the Ansvar film "Danger Level" again using quite high speeds.

Thus one cannot necessarily tell by just looking at a person (even closely) that he is unfit to drive. In fact, if no impairment occurred before signs of intoxication appeared we would surely allow our airline pilots to drink before flying. However, we do not. It would be interesting to see the reactions of any readers of these proceedings who, before boarding a plane, met the pilot coming jovially out of a bar indicating to them that he was about to 'wind up the elastic'.

Our respective communities must come to understand that impairment cannot be equated to drunkenness or intoxication. It should be added that the extraordinary group of circus and parlour tricks known as 'sobriety tests', for example, walking a line, balance tests and so on, are *not* measures of driving ability. They simply provide a rough estimate of the degree of intoxication.

The best illustration I have seen of this point was a drunken driver with a blood alcohol level of .258% who ran into a stationary pole on the sidewalk. He was able to stand on his head 3 times, a feat I cannot do when cold sober. However, I found he only did this trick when intoxicated and was in fact so drunk he went to sleep, snoring while I took his blood for testing.

At the 4th International Conference on Alcohol, Drugs and Traffic Safety (7), nearly ten years ago, a working party on the role of the clinical examination of the drinking driver concluded with the statement that "it was unanimously agreed that clinical examination is of no practical value in detecting impairment of the ability to drive properly" (p. 324).

Other developments in fields relevant to drinking and driving have complicated the issues, for example, the high powered car, speed, advertising for petrol and tires, the image of drinking being "with it" aimed at youth, and the development of the outer suburban beer farm with acres of car park. Nevertheless, the Breathalyzer legislation together with some sociological research has thrown some targets into relief.

Thus, we in the traffic field are very similar to the chest and tuberculosis physicians who are having to learn about alcohol and alcoholism because the alcoholic in the Victorian community is becoming virtually the reservoir of T.B. We in the traffic field, who started off with drinking and driving, are now also in the middle of the alcoholism field. That is, many aspects of alcoholism have to be considered if we are to make any headway with the drinking-driving problem.

The probability that an arrested drinking driver has an alcohol problem tends to make it nonsensical to cancel his licence only to return it to him in 3 or even 2 months time, without any attempt at dealing with the original problem behaviour. Many of our magistrates are adjourning the case, allowing the driver to continue driving. To me this is like attending to a badly injured alcoholic pedestrian, fixing up his injuries over months, and sending him on his way with no attempt to diagnose and treat the alcohol problem that produced the fractures in the first place. One must not only take drinking drivers off the road but also deal with the early development of the dangerous drinking habits indicated by a high alcohol level, particularly in the 18-24 year old male.

From my experience in the field I feel that dealing with drinking habits will be a waste of time in about 40% of cases. However, I also feel that results with the remaining percentage will be very good.

What we specialists in the field know, discuss, and indeed live with in our day to day work, is a closed book to so many of the community. Perhaps the key word is ignorance – ignorance not only of the extent of the problem but often also ignorance of the fact that there is a problem. This indeed seems to be the theme that the young drinking driver comes up with if put into a therapeutic learning situation about alcohol, "we didn't know, nobody told us".

There is a big job ahead of us all in Victoria, and I suspect elsewhere in the motorized world, to end this ignorance once and for all. Once the public is educated there will be dividends in many fields other than those of alcohol and the motor car.

REFERENCES

1. Birrell, J.H.W., Blood Alcohol Levels in Drunk Drivers, Drunk and Disorderly Subjects and Moderate Social Drinkers, *Medical Journal of Australia* 2, 949 (1965).
2. Birrell, J.H.W., A Note on Automobile – Tram (street car) Fatal Accidents and Alcohol in City of Melbourne, *Medical Journal of Australia* 2, 1 (1967).
3. Birrell, J.H.W., A Preliminary Note on the Drinking Driver in Victoria, Australia since 1966. *Medicine Science and the Law,* January 1970, p. 38.
4. Birrell, J.H.W., A Comparison of the Post-Mortem Blood Alcohol Levels of Drivers and Passengers Compared with those of Drinking Drivers who Kill Pedestrians. *Medical Journal of Australia* 2, 945 (1971).

5. Birrell, J.H.W., *Drinking Driving and You*, Sun Books, Melbourne, 1974.
6. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., and Zylman, R., The Role of the Drinking Driver in Traffic Accidents, Report of the Department of Police Administration, Indiana University, Bloomington, Indiana, 1964.
7. Department of Police Administration, Bloomington, Indiana, *Alcohol and Traffic Safety: Proceedings of the 4th International Conference*, Indiana University, Bloomington, Indiana, 1966.
8. Duncan, J., unpublished data, Canberra, 1974.
9. Lane, J. C., *Alcohol – The Search for a Counter Measure*, unpublished paper, 1973.
10. Lucas, D. and Smith, W., Point Zero Eight, A CTV film, Toronto, 1966.
11. Lovibond, S. H., *Danger Level.* The Warwick Farm Project on Alcoholism and Drug Dependence, Ansvar Insurance Company, Australia, 1971.
12. McCallum, N.E.W., Chemical Testing for Alcohol and Road Accidents, *Medical Journal of Australia* 1, 1025 (1971).
13. Ots, E. Y., *Drunken Drivers. A Follow-up Study of 300 Drivers Convicted of Drunk Driving Offences,* unpublished paper, 1973.
14. Phillips, Sir. P., *Report of Royal Commission into the Sale, Supply, Disposal and Consumption of Liquor in the State of Victoria.* Victorian Government Printer, 1965.
15. Raymond, A., A Comparison of Breathalyzed Drivers with the General Driving Population, *Australian Road Research* 4, 45 (1972).
16. Raymond, A., Unpublished data, 1972.
17. Simson, R., Unpublished data, 1972.

SECTION V

Public Education and Information

Program Committee	*Head:* W.B.G. REYNOLDS
	JEAN L'HOSTE
	JAMES W. SWINEHART
	G.J.S. WILDE

Drunk Driving: Outline of a Public Information and Education Program

Dwight Fee[1]

For the past three years the Department of Transportation has been engaged in an extensive, nationwide public information and education program on the subject of drunk driving. This program has included research into public knowledge and attitudes on various alcohol safety issues; cooperative public education programs with governmental and private organizations; plus 35 independent public education programs conducted by local Alcohol Safety Action Projects. Meanwhile, a study of the use of mass media for highway safety required by the Congress has been completed.

Rather than attempting to discuss any single aspect of the program in depth, this paper reports on the status of the total program. It describes the activities and interests of the National Highway Traffic Safety Administration (NHTSA) in public education on this topic, indicates some of the public opinion survey research which is underway, and suggests a few priorities and plans for the future in hopes that we might discover mutual goals for collaboration.

THE MESSAGE

Perhaps the best way to describe the mass media program is to describe the materials developed to date for what we have called the Four Waves. The assumptions and objectives which underlie them will be made plain. The basic premise of the entire Alcohol Countermeasures Program is that it is the excessive, abusive use of alcohol among a relatively small segment of drivers that causes most alcohol-related fatalities, rather than normal, moderate use.

In 1971 this was a unique definition of the drunk driving problem. A national survey at the time showed that more than half of our citizens believed to the contrary: that is, they believed that the worst culprits in alcohol crashes were the great mass of social drinkers. Thus, we had the job of a) convincing the public, key officials and professionals of a new definition of the problem; b) of motivating them to take new and different kinds of actions to identify, control and treat the problem drinker-driver; and c) of raising new hope that something could be done about this age-old problem.

Therefore, in the First Wave of creative materials the focus was on these problem awareness issues. In print there were four magazine and newspaper advertisements, each in a variety of sizes. The headlines indicate the theme:

---

[1] U.S. Department of Transportation, Washington, D.C., U.S.A.

TODAY YOUR FRIENDLY NEIGHBOR MAY KILL YOU . . . BY THE TIME YOU FINISH THIS MAGAZINE A DRUNK DRIVER WILL HAVE KILLED SOMEONE . . . HIS DRINKING PROBLEM IS NOTHING COMPARED TO HIS DRIVING PROBLEM . . . ONE OUT OF EVERY FIFTY CARS ON THE ROAD IS DRIVEN BY A DRUNK DRIVER.

One particular ad mentions the guy next door who may have a drinking problem, pointing out that no matter how nice he is, if he drives when he is drunk, he is a potential killer. It goes on to say that problem drinkers killed 19,000 people in car accidents in the previous year, and explains the nature of the heavy drinking – for example, eight drinks in two hours – that characterizes the problem drinker-driver. The advertisement then goes on to mention the countermeasures necessary to "get the problem drinker off the road. For his sake. And yours."

The campaign was introduced in the 100 largest markets in the United States. A variety of material was distributed over the radio. On television, actor Dana Andrews presented a straightforward exposition of the scope of the problem and the means toward its control.

The Second Wave of the program tried to personalize the problem by depicting the consequences of drunk driving and to continue to portray the problem drinking, which is involved in most alcohol related deaths on the highway. Some of the ads were created for specialty books and men's magazines.

The headlines continue to drive home the point: A DRINKING PROBLEM COULD KILL HIM . . . A DAY IN THE LIFE OF A RISING YOUNG PROBLEM DRINKER . . . THE WORLD'S MOST EXPENSIVE OPTION: LAST YEAR COST 19,000 LIVES.

Another ad describing the 'rising young problem drinker' introduced a new appeal. It concludes, "If you know someone who's killing himself with alcohol – but hasn't yet killed anyone with a car – sit him down. Get into his head. Talk with his doctor, clergyman, whoever he's close to." It also included a plug for supporting official countermeasures.

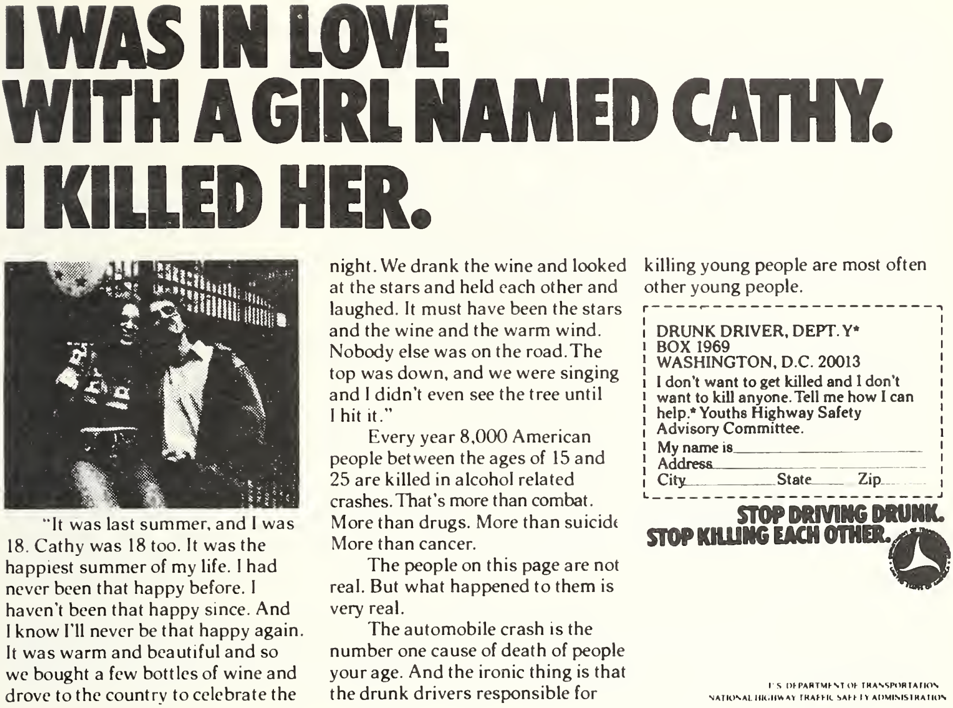
A high priority for NHTSA is the problem of youngsters being overly involved in fatal crashes. A special campaign was aimed at the young to warn them that about 8,000 persons under 25 are killed in alcohol-related crashes, usually at the hands of a driver who is also under 25. The number one killer of young Americans is truly – young Americans.

Figure 1 is a sample of one of the ads most popular with campus editors. We are quite proud of the 19 major awards given these advertising materials during 1973.

When people responded to these ads by writing to us, they were sent pamphlets outlining the scope and nature of the problem and the countermeasures, along with information on the relation of blood alcohol level and crash risk. The main purpose of the pamphlets, however, was for distribution at the local level where countermeasure programs were being organized.

As mentioned above, a great deal of persuasion was aimed at professional and official groups whose practices and priorities we were trying to change. Ads were prepared for their publications.

For law enforcement officers our aim was to encourage them to give higher priority to alcohol in traffic and to make them a part of a community-wide effort to identify problem drinker-drivers. The ad they received pointed out that, in an average



I WAS IN LOVE WITH A GIRL NAMED CATHY. I KILLED HER.

"It was last summer, and I was 18. Cathy was 18 too. It was the happiest summer of my life. I had never been that happy before. I haven't been that happy since. And I know I'll never be that happy again. It was warm and beautiful and so we bought a few bottles of wine and drove to the country to celebrate the night. We drank the wine and looked at the stars and held each other and laughed. It must have been the stars and the wine and the warm wind. Nobody else was on the road. The top was down, and we were singing and I didn't even see the tree until I hit it."

Every year 8,000 American people between the ages of 15 and 25 are killed in alcohol related crashes. That's more than combat. More than drugs. More than suicide More than cancer.

The people on this page are not real. But what happened to them is very real.

The automobile crash is the number one cause of death of people your age. And the ironic thing is that the drunk drivers responsible for killing young people are most often other young people.

DRUNK DRIVER, DEPT. Y*
BOX 1969
WASHINGTON, D.C. 20013
I don't want to get killed and I don't want to kill anyone. Tell me how I can help.* Youths Highway Safety Advisory Committee.
My name is____________________
Address______________________
City__________ State_____ Zip_____

STOP DRIVING DRUNK. STOP KILLING EACH OTHER.

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Figure 1 *Example of an advertisement.*

year, there are 18,000 murders committed in the United States – compared to 27,000 alcohol-related traffic deaths.

We wanted the judges and attorneys to cooperate in using presentence investigation and legal resources to identify and deal effectively with alcohol-dependent people.

Our aim with physicians was to have them deal with driving issues when they encountered problem drinkers among their patients.

There were brochures to spell out details of specific countermeasure activity for the key professions and official groups, that is, for the courts, doctors and police.

Having an understanding of the problem and being willing to support official action to combat it, is not enough. What else can the individual do? Some new objectives emerged for the Third Wave of the advertising which began in the Fall of 1973.

The basic objective of phase III advertising was to stimulate individuals to raise the issue of excessive drinking and driving as a social, peer group concern. It was to make excessive drinking and driving an explicit social concern for people where they live. In this wave we wanted to help the citizen raise this issue, to get it out into the open so that it could not be deliberately or inadvertently ignored. We aimed at getting Americans to see the responsibility and opportunity for every citizen to become involved in the prevention of drunk driving. We hoped to achieve this by stimulating discussions among individuals in their peer groups so that the topic could be treated with appropriate maturity and concern.

The second objective of phase III was to describe specific steps or actions which individuals can take to reduce intoxication and to prevent excessive drinkers from driving. These may range from the role of the hostess in preventing excessive drinking to methods for persuading someone to give up his car keys and accept a ride home.

Third, we continued to seek support of countermeasure programs and to encourage citizens to obtain implementation of these programs in their communities.

The fourth objective, educating young drivers about the issues involved with alcohol and highway safety, was of high priority.

The new campaign in Third Wave calls for personal and decisive action. The theme has become: "When a problem drinker drives it's your problem." Here is a sample ad:

"When would *you* rather deal with a problem drinker . . . at the party, or after the party?"

This particular ad in the series was also an award winner. It reads in part:

> *He killed himself. He didn't mean to. But he had lost control of his drinking. And after the party, he lost control of his driving and killed himself.*
>
> *Now his friends shake their heads and stare at the ground and wonder why. But the sad fact is his friends weren't his friends. His friends let him die.*

The ad concludes:

> *If you are really his friend, don't help him drink. If he has been drinking, don't let him drive. Drive him yourself. Call a cab. Take his car keys. Everything you think you can't do, you must do.*

The radio materials, again in a variety of styles, also raise the issue of personal responsibility. Two television commercials in this wave depict situations where significant others have responsibilities for preventing drunk driving by people close to them.

The current Fourth Wave of materials moves to specific calls for action. They seek to create social sanctions for the kinds of behaviours we are seeking to stimulate. Small gestures such as 'calling a cab', 'paying for the taxi', and 'driving him yourself' are the kinds of personal steps we want to foster.

Another ad points out to both sexes that when a man and woman go out together, there is no rule that says the man has to drive.

There are similar versions for youth publications. However, we refer to 'friends who have had too much to drink', instead of 'problem drinkers'. In addition, there is a brochure offering suggestions for responsible hosting. It describes steps to take before the party and after the party, if it comes to that, to prevent a friend from driving under the influence. The 'friends' theme is carried over to radio announcements and television spots.

Through these successive waves of creative materials the development of the strategies and appeals can be seen.

THE MEDIA AND THE PUBLIC

A vigorous effort has gone into the placement of these materials in public service space. These figures on placement are based on careful sampling of the media and take into account the fact that most of the placement has not occurred in prime time. By the second year the campaign achieved 23½ billion adult impressions and received 32 million dollars worth of exposure.

The media have cooperated very well in returning questionnaires indicating use of the materials, including the time at which the spots appeared, to yield these estimates for print, radio and television. Table I lists the amounts of money spent on advertising by some of the leading advertisers of commercial products. The 32 million dollars for the alcohol safety campaign fits in just behind the leading beer advertiser but ahead of United Air Lines.

TABLE I *Leading Advertisers in 1973 by Category*

Advertiser	$ million
Proctor and Gamble	310.0
Sears and Roebuck	215.0
General Foods	180.0
General Motors	158.4
Heublein	77.8
Coca-Cola	76.0
Goodyear Tire and Rubber	72.6
Anheiseur Busch	36.5
United Airlines	28.8
Exxon	28.2
Wrigley	28.1

(Source: Ad Age)

Public support for countermeasures has grown. In 1970, only about 58 per cent of the respondents in our survey were willing to pay more taxes to support "a program that would reduce alcohol-related traffic accidents by as much as a third or half". Today, we find that 85 per cent of those interviewed agreed that people should support strict law enforcement to reduce the drunk driving problem, even if it means higher taxes.

To test the effects of the campaign on personal responsibility, we added two questions to national surveys being conducted for the National Institute on Alcohol Abuse and Alcoholism (NIAAA) by Lou Harris in 1973.

We asked people whether they had discussed the topic of drinking and driving in the past month and then asked, "During the past month have you or others that you know tried to prevent someone who had been drinking from driving an auto?"

During the period the proportion of those who discussed the topic rose from 26% to 32%. Those who tried to prevent someone from driving rose from 16% to 21%.

Interestingly, those more aware of alcohol advertising were more likely to have taken positive action. While these results are encouraging they also indicate a need for continuing public education, and we do not regard this single poll as sufficient to evaluate the effectiveness of the advertising program.

Current plans call for copy testing of all television advertising this year and for tracking research on the overall campaign throughout the year. In the meantime, we are seeking to refine our public education goals and activities regarding the specific actions we can realistically ask Americans to take, regarding the control of drinking and of drunks when driving is going to occur.

PRESENT RESEARCH

Although all the results are not in, I will outline in brief the strategic research effort we have been engaged in.

The objectives of the research are to define appropriate target audiences in terms of (a) the size of the groups; (b) their attitudes toward drunk driving and problem drinkers; (c) the situations in which they encounter drunk drivers; and (d) their willingness to help: types of action they are willing to take to stop drunk drivers from driving.

The main phase of the study consisted of 1,660 personal interviews averaging about 75 minutes each and conducted among a national probability sample of adults between the ages of 18 and 55 with the aim of analyzing adult and youth audiences.

Some Preliminary Results

The purpose of the interview was totally unknown to the respondents when they were asked to rate the importance of various national problems. It is interesting to note that "Drunk Driving" ranked fifth in terms of the number of people (76%) who felt it was an "Extremely or Very Important" problem. This placed it ahead of such issues as Pollution of the Environment, the Energy Crisis and Unemployment (Figure 2).

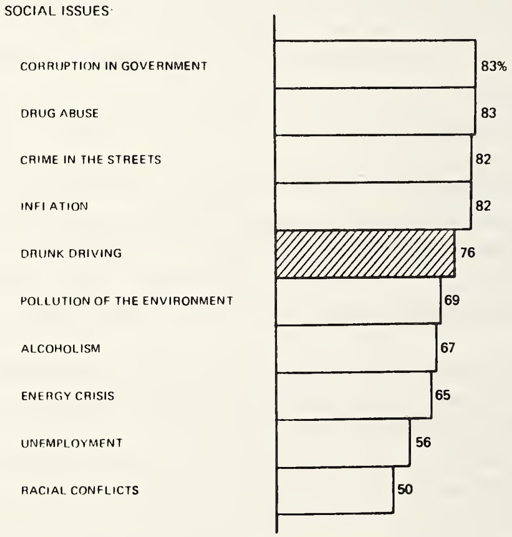


Figure 2 *Percentage of the sample rating drunk driving and other social issues as "extremely" or "very" important (N = 1660).*

We found that 69 per cent of the persons interviewed had been in a social or business situation where alcoholic beverages were served over the past 3 months. We call these Alcohol Related Situations (ARS). This was reduced to 54 per cent when a frequency of at least once a month was considered (Table II).

Eighty per cent of the locations of these ARS proved to be outside the individual's own home (Table III). The admission that drinking actually took place in a car in

TABLE II *The Frequency with which Respondents found themselves in a Social or Business Situation where Alcoholic Beverages were Served (N=1660)*

Alcohol related situations in past 3 months	%	
Respondents in situation	69	
Respondents not in situation	31	
Frequency in alcohol related situations in past 3 months		
Daily	3	54
5-6 times a week	2	
2-4 times a week	10	
Once a week	15	
Once every 2 weeks	8	
Once every 3 weeks	5	
Once a month	11	
Once every 2 months	5	
Less than once every 2 months	10	
Not in situation	31	

one per cent of the cases confirmed something that was indicated in our qualitative group sessions, which preceded the survey.

TABLE III *Locations at which Respondents found themselves in an Alcohol Related Situation (N=1145)*

Location	%	
Social occasion in own home	20	
Friend's/Relative's home	43	80
Bar, restaurant where meal was primary reason for attending	15	
Bar, restaurant where meal was not primary reason for attending	15	
Recreational event	6	
In a car	1	

When we compared the involved individuals (those in ARS once a month or more) to the balance of the sample, some interesting differences in the demographic profile were observed. More of the Involved Group tended to come from households where the overall income was over $20,000 a year and where the head had college experience and was in a professional or managerial occupation. The individuals themselves were more often men, under 35, and from the North East and North Central Regions (Figure 3).

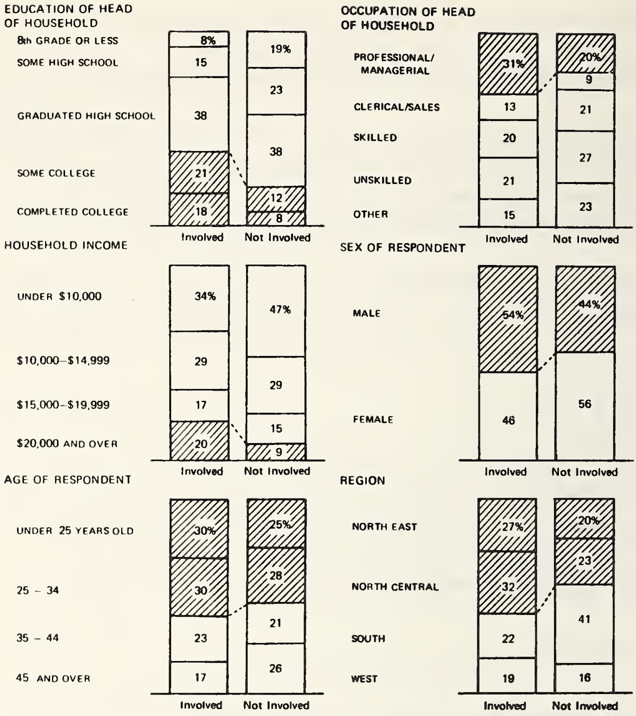


Figure 3 *A demographic comparison between persons involved in ARS once a month or more (N = 896) and those involved less than once a month (N = 764).*

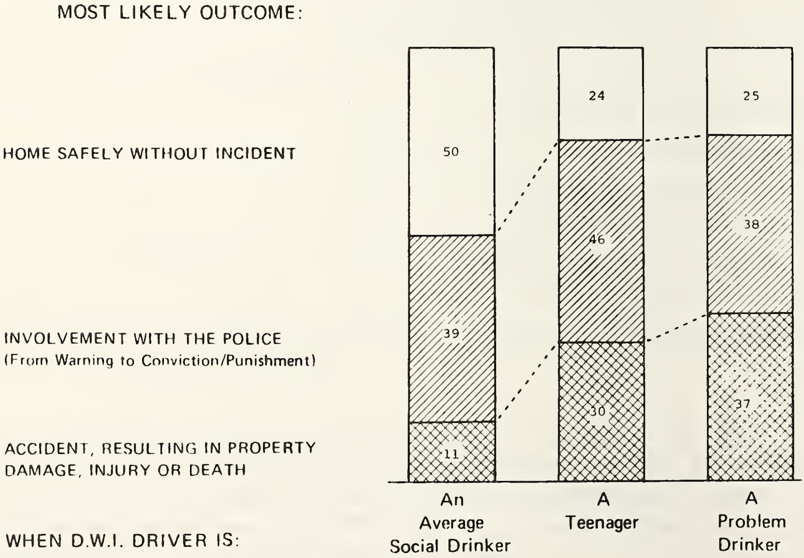


Figure 4 *Distribution of ratings on "most likely outcome" for 3 groups of DWI drivers (N = 1660).*

Our survey contained a question asking what was seen as the most likely outcome when persons from the following groups drive: a) drunken Problem Drinkers, b) drunken Teenagers, and c) drunken Average Social Drinkers. Only about 25% of the Involved respondents felt the Teenager and the Problem Drinker could get home safely without incident and 30 per cent or more in each case foresaw an accident (Figure 4). The Social Drinker, on the other hand, was seen as getting home safely by 50 per cent and only 11 per cent predicted an accident. In other words more than three times as many respondents felt an intoxicated *problem drinker* would be more likely to have a serious accident than an average *social drinker* who is driving while intoxicated.

A main reason for undertaking the study was to evaluate the measures people who are involved in ARS might take when dealing with excessive drinkers. To do this we factor analyzed the scores of 60 possible countermeasures and countermeasure situations. The result was to reduce the list to a manageable 21 unique actions. Of these, 3 have high potential for action and 10 a moderate potential (Table IV). The main study will deal with the full range of actions and alternatives for approaching them.

TABLE IV *Countermeasures People Involved in ARS might take toward Excessive Drinkers*

HIGH LIKELIHOOD POTENTIAL FOR ACTION:

Offer to drive home a close friend or relative

Invite a close friend or relative to stay over

Plan to serve food at a party with the drinks to reduce the effects of alcohol

MODERATE LIKELIHOOD POTENTIAL FOR ACTION:

Call a taxi for a person who drank too much

Treat seriously any conversation on drinking and driving, particularly when people are treating it lightly

As a host/hostess, refuse to serve more drinks to a guest who is becoming intoxicated

Take the keys away or restrain a close friend or relative

Offer to drive a casual acquaintance or someone you just met from your own or a friend's home

Attend or host a party where no alcoholic beverages are served

Report to authorities stores or bars that sell alcoholic beverages to minors

Plan a party where drinking is cut off at a certain hour and replaced with non-alcoholic beverages and food

As a host/hostess, plan for sober transportation or a place to stay for party guests

In a bar, offer to drive home a casual acquaintance or someone you just met

CONCLUSION

In conclusion I would like to mention future priorities for this program:

The first is to document the effects, wherever possible, of our public education programs at the national level. This has been made a priority for ASAP public education programs as they develop objectives and programs designed to impact specific target audiences. Funds have been made available for continuation of many of the ASAPs and selection of these projects will in part depend upon their ability and willingness to undertake such measured programs.

The second is to give support and to upgrade the capability of States and communities for the purpose of conducting professional communication programs. This involves long term, planned programs using research to establish needs and provide feedback on effectiveness. We plan to offer training seminars and on-site assistance to State agencies engaged in public education activities.

The third priority, is the coordination of our activities with governmental, private and voluntary organizations nationally and internationally.

Just a few preliminary findings from this study concerning the means for prevention of drunken driving through the modifications of the behaviour of 'by-standers' have been outlined here. Not all aspects of this alcohol safety public education effort, the ASAP programs nor the mass media study have been discussed. More detailed reports can be obtained from our office in Washington.

Public Information Programs Related to Alcohol, Drugs, and Traffic Safety

James W. Swinehart[1]

In many countries, attempts to reduce highway crashes involving alcohol or other drugs include public information campaigns as well as various measures designed to control the distribution or sale of mind-altering substances. In a sense, most of these campaigns can be regarded as efforts to remedy the failure of other control measures, since the usual target is the consumer who is assumed to be in a position to choose whether to drive while in an impaired condition. A great many drivers decide to do so, usually without harm to themselves or others – a fact they have learned which makes it extremely difficult to convince them that they are at greater risk than drivers whose perceptual and motor skills are unimpaired. Given this double burden, it is not surprising that campaigns aimed directly at the drinking driver have not been very successful.

In the last few years, a number of campaigns have moved beyond attempts to inform or persuade this particular target audience and have focused on what might be termed informal influence agents – friends, party hosts, and family members. Such people are often able to control a person's access to alcohol or drugs, or to a car, or both. In contrast to law enforcement personnel, they are able to exert influence before a violation or accident occurs, and they are not viewed as agents of a legal system with the power to punish. The use of this indirect approach is an encouraging development, in part because it is potentially capable of recruiting large numbers of people personally concerned about the impaired-driver problem and available at the times and places where positive action can be taken to reduce it.

Several other target audiences for public information programs have been identified in addition to those noted above. Many programs are designed for the general public, usually to increase awareness of the problem or to solicit support for control measures; some deal exclusively with young people; others are aimed at minority groups, employers, doctors and lawyers; and a relatively small number are designed to reach legislators, opinion leaders, the press, and educators.

THEMES

The themes or appeals to be considered below have been used in campaigns directed to one or another of these target audiences, although it will be obvious that most of them are appropriate only in campaigns intended for the potential offender.

---

[1] Children's Television Workshop, One Lincoln Plaza New York, N.Y. 10023, U.S.A.

Threat of loss: life, friend or loved one, attractiveness (disfigurement), financial costs, respect of others, driver's license, freedom (jail, etc.), employment.

Personal responsibility, maturity.

Responsibility to others (as parent, friend, host).

Value of knowing personal limits.

Separation of drinking from driving.

Need for public support of control measures: enforcement, detection, treatment, punishment.

Legal limits vs. "safe" limits.

Factors influencing relationship between alcohol consumption and blood alcohol concentration (BAC) such as weight, rate of drinking.

Number of drinks producing various levels of BAC.

Relationship between BAC and risk of crash involvement.

Driving-related factors impaired by alcohol or drugs: vision, reflexes, judgment.

Only the last four of these themes are "informational" in a strict sense; the others utilize some form of threat, invoke normative values, or appeal to concern for the common good.

INTENDED RESULTS

Although the ultimate objective of campaigns in this field is a reduction of injuries or fatalities on the highway, most campaigns focus on one or more intermediate objectives which are assumed to be related to this outcome. Appropriate changes in beliefs or attitudes, for example, are assumed to lead to desired changes in behavior, which in turn are expected to produce a lower incidence of violations and crashes. In the same way, institutional or organizational changes in a desired direction are presumed to reflect the influence of public information programs and establish an improved climate for reduction of the problem. Setting specific objectives for campaigns is obviously a critical step in the process of evaluating their effects, since the inappropriate use of second or third order objectives will almost guarantee that any program will appear to be a failure.

Programs dealing with drug abuse have been used widely in recent years, but very few of these have dealt specifically with traffic safety. Thus the examples of intended results given below have been taken from campaigns on drinking and driving rather than from those concerned with drugs. In most cases, the desired outcomes were inferred from campaign materials.

Knowledge or Belief

It was hoped to bring about an increased awareness of:

Magnitude of drinking-driver problem.

BAC limits (legal vs. illegal, impaired vs driving under the influence (DUI)).

Number of drinks producing various levels of BAC.

Relationship between BAC and risk of crash involvement.

Factors affecting intake-BAC relationship.

Myths about methods of sobering up.

Existing countermeasures programs.

Laws regarding tests, penalties, etc.

Methods of detecting, prosecuting, and treating drunk drivers.

Treatment methods and their effectiveness.

Risk of encountering a drunk driver.

Personal drinking limits.

Nature of organization sponsoring campaign.

Attitude

The material was designed to produce acceptance of, or favorable attitude toward:

Various control measures (screening devices, pre-arrest breathtesting, special patrols, videotaping, license suspension or revocation, treatment programs, etc.).

Use of public funds for control measures.

Legal BAC limits.

Limiting use of alcohol by self or others.

Organization sponsoring campaign.

Behavior of Individuals

The behavior changes desired were:

Altered alcohol consumption (frequency, amount, location).

Decreased driving after drinking.

Increased efforts to discourage others from driving after drinking.

Writing letters to editors, public officials, etc.

Contributing time or money to relevant voluntary groups.

Requesting further information about drinking and driving.

Responses of Organizations and Institutions

These covered:

Inclusion of alcohol/safety information in school curricula.

News media coverage of relevant items (frequency, placement, treatment, size).

Editorials on alcohol/safety (frequency, treatment, etc.).

Referrals to alcoholism agencies from other agencies (including police).

Ratio of arrests to convictions on drinking-driving/charges.

Reductions of DUI to impaired.

Endorsements of programs for detection and control.

Funding of control programs.

Hospitals' admission of alcoholics for treatment.

Operation of employee alcohol programs by local industry.

EXAMPLES OF CAMPAIGN MATERIALS

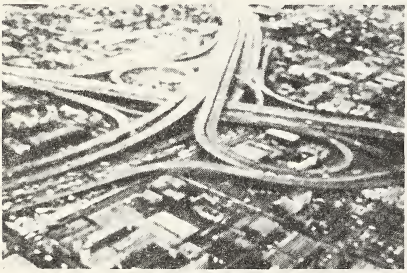
Some of the themes and intended results listed above can be illustrated by the following group of television spot announcements, chosen from the collection of the Public Communication Group at the University of Michigan's Highway Safety Research Institute.

1. One spot, prepared for the Denver Alcohol Safety Action Project (ASAP), uses humor and animation to show that drivers who have been drinking have an unrealistically low perception of risk. The message is intended for people who may drink before driving but who retain the ability to restrict their intake *i.e.*, social drinkers rather than problem drinkers. The use of a cartoon technique may serve to make the message less threatening and thus arouse fewer defensive reactions among viewers.

2. "Ending the Party," produced for the Columbia ASAP, offers several specific suggestions as to means by which risks can be reduced for people who have been drinking at a party. The message need not be restricted to that context, of course, and its "how to do it"/information probably makes it useful to people who have already accepted the basic premise.

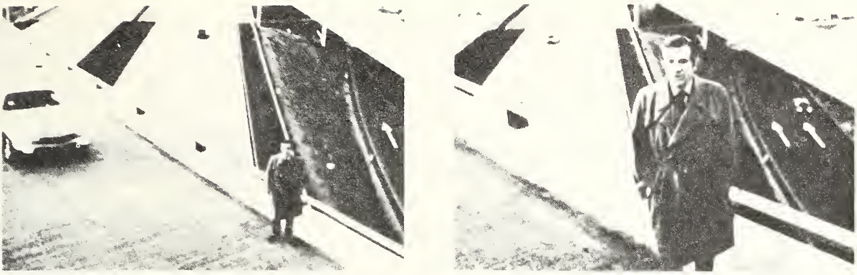
3. A recent spot from the U.S. Department of Transportation, "Poker" represents an effort to elicit concern on the part of people who know someone who drives after drinking too much. It does not offer explicit recommendations for action but may legitimize attempts by friends to protect a problem drinker from himself.

4. Dana Andrews, a well-known actor, adds authenticity to his comment about the number of problem drinkers on the road by stating that he is an alcoholic (Figure 1). This U.S. Department of Transportation spot is aimed at the general public and is apparently designed to increase awareness of the seriousness of the problem and the need for constructive control measures.



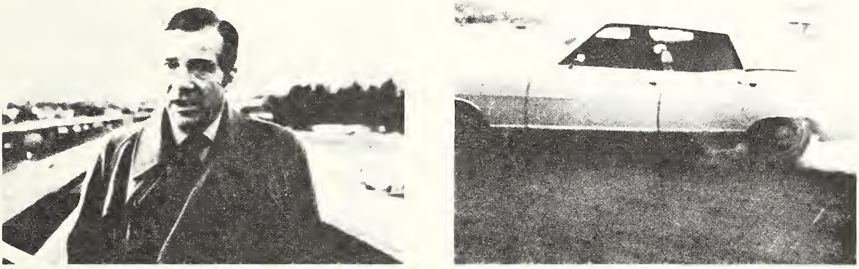
It's 5:00 in the afternoon on the Santa Monica freeway . . .

and one out of every fifty drivers is drunk—at 5:00 in the afternoon.



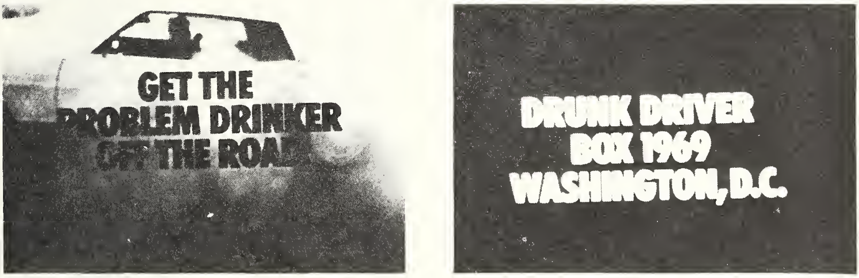
Does that surprise you? It doesn't surprise me at all. I'm Dana Andrews and I'm an alcoholic.

I don't drink anymore, but I used to and I know that most drunk drivers aren't coming home after a night on the town and a couple of drinks.



They're heavy, serious, problem drinkers. They're sick and we have to help them . . .

because they can't always help themselves.



But they're killing people and we have to stop them—because they can't stop themselves.

Get the problem drinker off the road—for his sake and yours.

Figure 1

5. The use of a professional stunt driver in one spot produced for the National Safety Council demonstrates that even an expert driver cannot handle a car well after drinking. The message undermines the common rationalization by many persons who drink and drive that their driving ability is above average.

6. Another common rationalization is attacked in the spot by the Charlotte ASAP (Figure 2). Many individuals feel that if they drink only beer they are unlikely to get drunk, and thus would not be subject to greater risk behind the wheel.

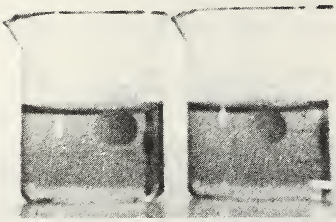
Here's something for that friend who thinks beer is safer than the hard stuff.

Say we could take a full shot of whiskey—86 proof—and squeeze out the pure alcohol.

Then say we could squeeze out the alcohol in a 16-ounce beer.

Here is the real hard stuff and the amount is the same.

One beer, one shot. That's something for your friend to think about.


But if he's had one too many to think clearly, think for him—

and don't let him drive.

Figure 2

7. The use of special police patrols gives substance to another spot from the Charlotte ASAP regarding the increased risk of being picked up for drunk driving. This type of message is probably more effective with social drinkers than with problem drinkers, but the general point may be validly and effectively made with the former group. The theme line "Let's keep our friends alive" suggests that non-drinkers as well would be an appropriate target audience for this message.

8. If reducing crashes is a direct objective of a campaign, convincing the general public not to drive at a high-risk time of day may be at least as effective as aiming the same message at the relatively small number of persons who cause a disproportionate share of accidents. The Charlotte ASAP has done this in a TV spot which seems particularly appropriate for people who are more likely to be the victims than the causes of late-hour crashes.

9. An Oregon ASAP spot offers people a rationale for supporting a control effort through emphasizing the reality and seriousness of the problem. The use of a "talking head" approach rather than conveying the same information through a voice-over narration gives the film a somewhat static appearance, but using the site of a well-publicized crash tends to reinforce the basic message and does add some movement to the background.

10. An animation film, also from the Oregon ASAP, attempts to undermine in a humorous way some of the more common misconceptions about ways of sobering up after drinking. The target audience apparently includes both social and problem drinkers, though the spot would be unlikely to have any effect on the latter group.

11. "Good Old Harry" (Figure 3) caricatures the type of party host who feels people who feel that a seeming generosity is a greater value than moderation or responsibility to one's guests.

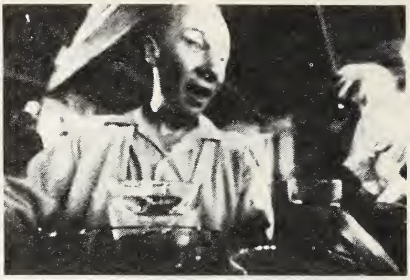
12. A fund-raising spot from the National Council on Alcoholism represents an attempt to generate a more sympathetic attitude toward alcoholics. It also illustrates the kind of campaign material related to alcohol but not to safety which contributes to the total pattern of impressions people receive through competitive public service advertising.

13. One spot from the AAA Foundation for Traffic Safety plays on the widely-used "know your limits" campaigns by ridiculing those who misinterpret or misuse the slogan. Whether this approach reinforces or undermines the effectiveness of campaigns which use the appeal in a straightforward way remains an open question.

14. Another spot from the AAA Foundation again takes a standard appeal ("coffee for the road," etc.) and by extending its attempts to counteract the belief that coffee can overcome the effects of alcohol. The target audience for this type of message may be social drinkers.

15. A National Safety Council spot which has received very wide circulation on American television is shown in Figure 4 but it has not produced a large write-in response to the specific appeal stated at the end. It is aimed at the general public and attempts to arouse concern about the magnitude and consequences of the drinking-driver problem.

A drink in your hands puts a smile on your lips, that's Harry's motto. And he'll get you to smile if it takes him all night.



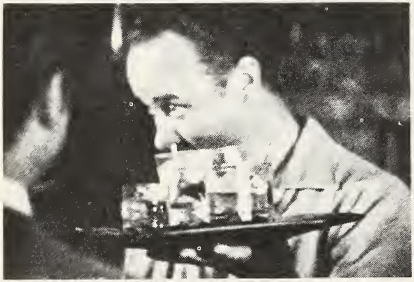
There's just one thing though. If Harry's such a good host, how come he makes you feel so bad?

How come when you wake up tomorrow your head will pound and you'll feel rotten all day long? How come?

Because Harry's a pusher—the neighborhood pusher.

There are nine million problem drinkers in this country—and most of them have a friend like Harry.

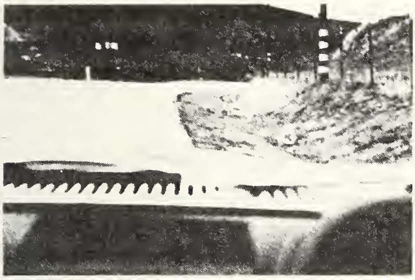
Good old Harry. With a friend like him, who needs enemies?



Meet good old Harry. The best host on the block.

Everybody has a good time at Harry's parties. Everybody. And nobody ever goes away sober, either.

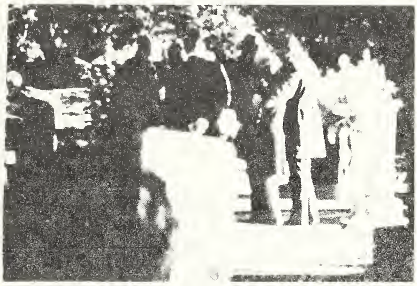
Figure 3



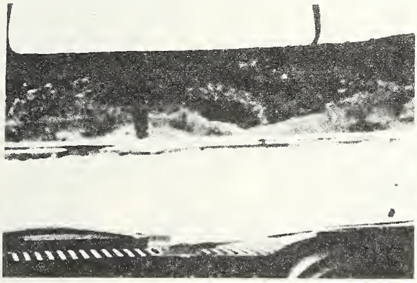
It's not the drink that kills on our highways . . . it's the drunk . . . the problem drinker . . .

the abusive drinker . . . the drunk driver.
Look at all he's done for us . . .

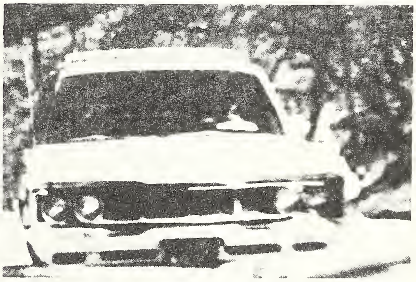
helped to eliminate the overcrowding in our schools . . .



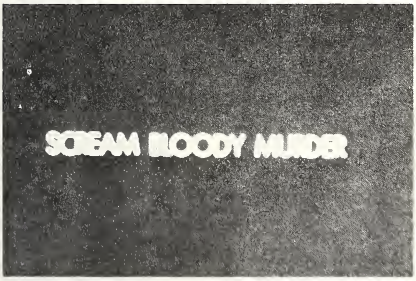
brought families together . . .



After all he's done for us, shouldn't we do something for him?



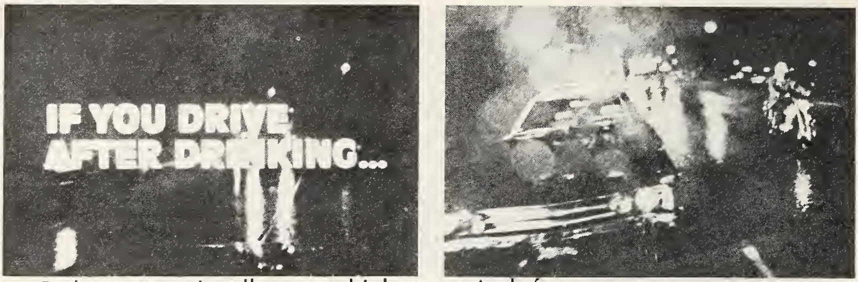
If he's sick, let's help him. But first let's get him off the road.



Do something. Write the National Safety Council . . .

and your voice will be heard.

Figure 4

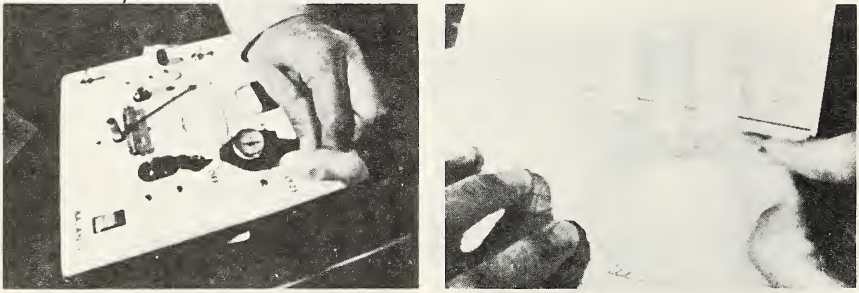


Perhaps occasionally you drink and drive—just those three or four drinks, enough to make you legally impaired

And for some reason you are stopped. Police officers are well trained at spotting drinking drivers.

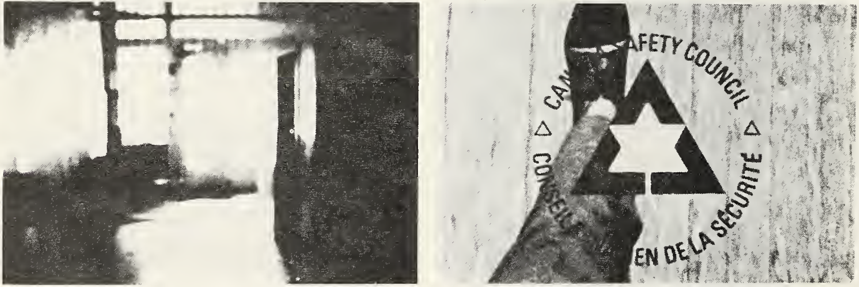
If you are suspect, you will be asked to submit to a mandatory breathalyzer test:

a 0.08 reading will result in your being charged.



Impaired driving is a criminal charge, and that's just how you will be treated.

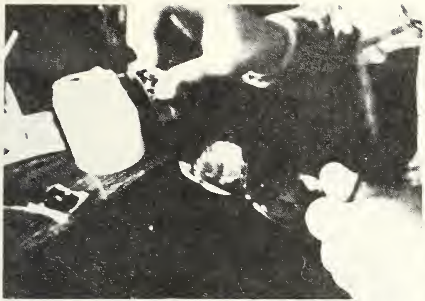
The police report and your breathalyzer reading will normally result in conviction.



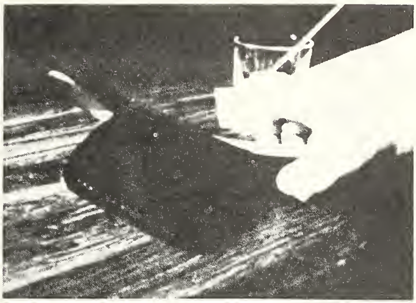
That's the way it is. Think about it next time you decide to save a few dollars on a cab.

This message was brought to you as a public service by this station and your safety councils.

Figure 5

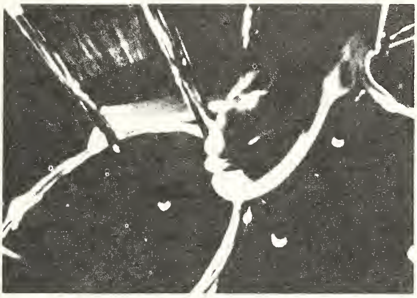


Your eyesight is now distorted, like looking through greased glasses.

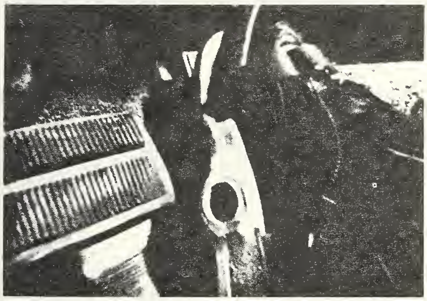


Your side vision is cut down by as much as 80%.

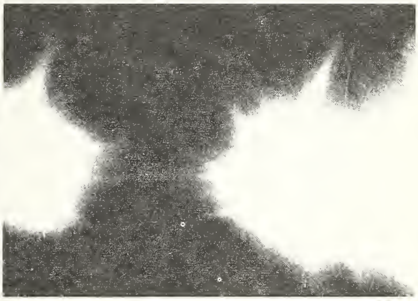
Your reaction time is all off,



as if you had weights on your feet.

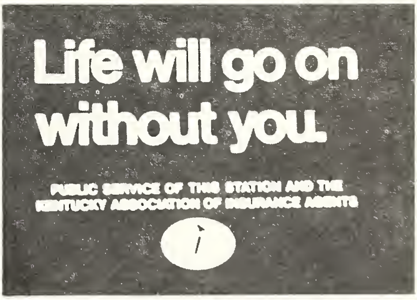


How would you like to try driving your car like this some night? A lot of people do.



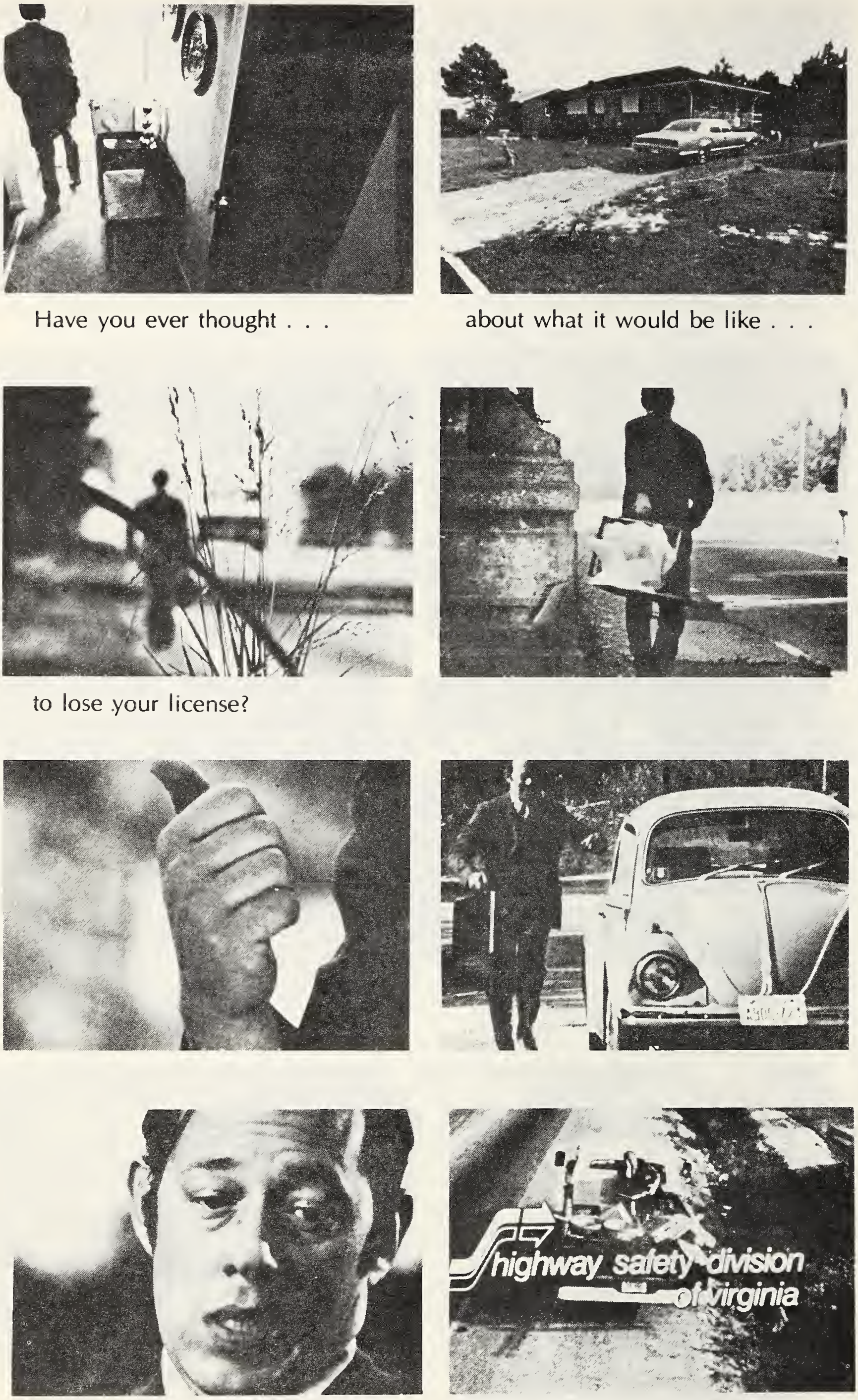
This is the way it is after you've had a few drinks then try to drive.

Shouldn't you think twice before trying to drive before drinking?


Life will go on without you.
PUBLIC SERVICE OF THIS STATION AND THE KENTUCKY ASSOCIATION OF INSURANCE AGENTS

You bet your sweet life you should!

Figure 6



Have you ever thought . . .

about what it would be like . . .

to lose your license?

Don't drink and drive!

Figure 7

16. Rather than assuming that alcohol and driving can be effectively separated by most people, a Canada Safety Council spot (Figure 5) is based on the fact that result from excessive drinking (Figure 6). It can be assumed to be directed to anyone this spot illustrated in Figure 7: the loss of your driver's license could produce some unhappy consequences.

17. One spot, prepared for the Kentucky Association of Insurance Agents, is unusual in that it attempts to dramatize the specific kinds of ability impairment which result from excessive drinking (Figure 6). It can be assumed to be directed to anyone who drives after drinking, and offers a means of increasing people's awareness of a condition which is normally very difficult to perceive accurately.

18. The Highway Safety Division of Virginia has a single and explicit message in this spot illustrated in Figure 7: the loss of your driver's license could produce some unhappy consequences.

CONCLUSION

Most campaigns on drinking and driving have not been evaluated in any systematic way, and as result it is not possible to provide definitive conclusions regarding the relative effectiveness of the appeals illustrated in these campaigns. Appropriate evaluations of actual effects in the field are obviously needed to furnish an answer to this and other questions.

Evaluation of Effectiveness of Public Education and Information Programmes Related to Alcohol, Drugs, and Traffic Safety

G.J.S. Wilde[1]

In this paper, I shall address myself to the following questions. What methods are presently available for the evaluation of the effectiveness of mass media messages for the promotion of road safety? What have we learnt, while using these methods, about the design of effective mass communication programmes? How do these effects compare with alternative countermeasure activity such as legislative change and enforcement? How can we learn to make mass communications more effective and, finally, what countermeasures for future use might possibly be derived from our present understanding?

I realize that detailed answers to these questions, supposing they were available, would demand more time than patience would endure. Therefore, I will concentrate on those factual findings and interpretations that I believe to be of major interest.

MEASURES OF CAMPAIGN EFFECTIVENESS

The ultimate goal and criterion of any safety publicity campaign is the reduction in the number of severity of accidents mediated through the action of road users. Accidents, especially the more serious and therefore more interesting ones, are relatively rare events, subject to marked statistical fluctuations over time and from site to site. This consideration, in combination with variance in reporting likelihood and procedures, makes accident statistics rather awkward as a practical measure in many research projects. Also, changes in accident tolls may be due to other concomitant factors, such as weather, seasonal variations, economic fluctuations, road engineering and increased seat-belt use, that is factors other than the one under investigation. Hence, intermediate criteria of campaign effectiveness are often applied, and evaluation efforts may take different forms.

For instance, one might consider (a) a reduction in the presence of alcohol in drivers involved in fatal and other accidents (whether at fault or not), or (b) an overall reduction in average blood alcohol concentration (BAC) levels in the road-using public at risk, but not necessarily involved in accidents.

Alternatively, one might deem a campaign effective if it is followed by (a) a reduction in those higher BAC levels considered to be critical in contributory effect to accidents, or (b) an increase in the public's knowledge of the dangers associated with high BAC levels and a negative attitude towards their occurrence.

---

[1] Department of Psychology, Queen's University, Kingston, Ontario, Canada.

Still other measures of effectiveness are an increase in the public's knowledge of laws dealing with drinking and driving, and the ability to recall elements of the publicity campaign (e.g. the slogans used or the media).

There can be no argument about the great difference in relevance between these criteria. A drop in the BAC levels of drivers involved in fatal accidents is a valid reflection of campaign effectiveness only if the total number of accidents occurring is also reduced. Another problem of this criterion is that a substantial reduction in the number of accidents is quite compatible with an *increase* in BAC levels among those killed.[2]

The remaining criteria have even more drastic shortcomings. Their use seems to be based upon the assumption that a change in knowledge will produce a change in attitude, which in turn will result in a change in actual behaviour. Some data, obtained in contexts other than road user behaviour, seem to corroborate this assumption, but other findings indicate that attitude change may follow behaviour change that was induced through different means (e.g. forced compliance or manipulation of reward conditions contingent upon the behaviour in question). It is to be regretted that the academic literature regarding cognitive, attitudinal and behaviour change (20) does not provide greater certainty in these matters. It may be concluded, however, that the use of non-behavioural indices of effect should be regarded with great caution, if not suspicion.

The problem is further complicated by the fact that the measurement of knowledge or attitudes necessitates a situation that brings its own weaknesses with it. Measurement is almost invariably verbal in nature and therefore suffers from the biases characteristic of an interview or questionnaire situation. The operation of response sets, and the desire to make a socially desirable impression upon the interviewer or experimenter are some examples of these difficulties. Verbal behaviour is instrumental, purposeful behaviour and therefore not necessarily expressive of the subject's behaviour tendencies under different conditions. Studies that encourage some confidence in the relationship between self-reported and actually observed road user behaviour (13) are rare and do not reduce the overriding need for observational data as dependent variable of campaign success.

A rather amazing example of the discrepancy between verbally assessed and actually observed behaviour was provided in an experiment on driver frustration (10). The driver of an experimental car was instructed to remain 'stopped' at a signalled intersection after the signal had changed to green. The effect of this frustrating event upon the driver of the car behind was investigated by measuring the time he took to sound his horn. Two different cars were used, an expensive, high status vehicle and a rusty, low status car. It was observed that the high status car produced significantly longer time lapses before honking occurred than the low status vehicle. A parallel study, in which the subjects were asked how they would behave in the two situations also produced significant results, but they were in the opposite direction.

Experience with road safety campaigns offers several examples of lack of concordance between questionnaire and road behaviour effects (35). Such discouraging results also seem to be common in the field of programmes against driving after drinking. The Canadian breathaliser legislation in combination with an accompanying publicity programme, has been followed by major cognitive and attitudinal changes; but no definite, measurable effect upon road accident rates occurred (5). A recent countermeasure programme conducted in Texas, made use of questionnaires and of BAC levels observed in roadside surveys as yardsticks of effectiveness. Major impact upon the level of knowledge in the general and the driving public was the result but the percentage of people driving at BAC levels ⩾ .10% remained unaffected. It amounted to approximately 11% of all drivers before and after an intensive one year campaign (28). Yet no fewer than two-thirds of these high BAC drivers said they had heard of the alcohol and driving campaign. A recent study carried out in Austria (29), gives us little information about the relationship between attitudinal, cognitive and behavioural changes as the campaign failed to measurably influence any of the variables. The author inferred from his study, however, that the longer the road experience of the driver and the better opinion he has of his own driving ability, the more often he drinks before driving. The latter was true particularly for persons between 40 and 55 years and was rare among those younger than 25. In Vermont, an educational campaign resulted in both cognitive and BAC changes according to roadside surveys (34). However, in a preliminary report, no rigorous statistical evaluation was made of the effects claimed and sample sizes were not mentioned. A Canadian campaign, carried out in Edmonton with Calgary as a control city, showed major cognitive and attitudinal changes on the part of the driving public, but a significant impact upon BAC levels remains to be demonstrated (11).[3]

---

[2] If for instance, among all those who drive after drinking, the social drinkers are most affected by the countermeasure, thereby reducing their share of the fatal accidents, the proportional contribution of the very heavy drinkers must necessarily increase. An increase in the proportion of those with BAC readings over the legal limit in the total number of drivers killed may thus be observed, and this would not be incompatible with a reduction in the rate of fatal accidents.

If changes in attitude and knowledge are not systematically related to changes in the critical behaviour, *i.e.*, the amount of drinking prior to driving, there seems to be even less justification for using the recall of the message or the media by a sample of respondents as a meaningful measure of campaign success as was done in some recent studies (14, 24).

LEGISLATIVE CHANGE AND ENFORCEMENT

It would seem fair to infer from the evidence presented so far that the effect of mass communication messages upon driving after drinking remains questionable. In view of this, one might ask what effects upon this behaviour may be expected from safety publicity? Mass communication has been demonstrated to be capable of bringing about changes in several elements of road user behaviour such as seat belt and head light use (35, 37). However, its persuasive impact may be insufficient to affect deep-rooted cultural habits among social drinkers, or sociopathic tendencies among problem drinkers and alcoholics. This reasoning would seem to favour a different approach with clear cut threatening consequences such as stiff penalties and intensive enforcement. However, what do we know about the actual effects of the law?

Let us first consider the few empirical studies regarding *special deterrence*, that is, the educational effect of a penalty upon an offender, manifested by a desirable behaviour change after the penalty has been delivered to that person.

---

[3] A calculated error seems to be present in Table XIV, p. 25 of the Edmonton study. The first chi-square value mentioned should read 4.2636 instead of 2.1628 (df = 1), indicating that a significant drop in BAC level also occurred in the control city. No evaluation is given of the significance of the difference in BAC reduction between experimental and control areas.

It is estimated that between 40 and 70 percent of those drivers whose licences have been suspended or revoked continue to drive. The longer the period of disqualification, the greater the likelihood that it will be disregarded[4] (3, 4, 8, 21). In one study (4) it was found that almost 40 per cent of all convicted drivers showed one or several cases of recidivism in a 12-year follow-up period.

Jurisdictions in West Germany which have mandatory jail sentences for drunken driving, when compared with other areas in that country where jail sentences are not mandatory, fail to show lower recidivism rates (3). As with the length of licence suspension, there is some evidence that the longer the jail sentence of the individual, the greater is the probability that he will commit the offence again. Of course, this does not necessarily imply a direct causal relationship[5] but it would seem to show that the special deterrence exercised by the law has little effect. The size of the penalty has not been shown to influence recidivism rate favourably. Studies carried out in Sweden (21) seem to offer an explanation of why this might be the case. The hardships following licence suspension, in combination with other conditions (such as the long delay between the traffic incident and the announcement of licence suspension that sometimes occurs) produce strong feelings of hostility and resentment towards the legal system and the authorities. These hostile feelings not only overshadow the feelings of guilt and shame, but create a state of mind incompatible with effective re-education and rehabilitation. These reactions may be further strengthened by the individual's awareness that undetected driving after drinking is so commonplace that he is put in the position of unsolicited martyrdom for his fellow motorists. Hence the feeling that society has committed a crime against his person.

Furthermore, it may well be that the potentially maximum effect of special deterrence upon a reduction in accidents is quite limited even if the functioning of the law in this respect were optimized. This is because only a relatively small percentage of all accidents occur to individuals who have prior accidents or violations. It has been calculated that more than 95 per cent of all accidents in a two-year period would still happen if all individuals who had three or more violations in the preceding two years were removed from the roads. Similarly, less than five per cent of all accidents would not occur in a three-year period, if all individuals who had two or more accidents in the preceding period of three years no longer drove (6). Consequently, whatever may be achieved through the special deterrent actions of the law should be viewed in the proper perspective of the total accident problem.

Next, we may compare the effectiveness of road safety publicity regarding drinking and driving with the *general deterrence* exercised by the law, *i.e.*, its preventive influence. Investigations have been conducted in several countries in conjunction with the introduction of new, usually more severe, legislation.

Measurements of BAC levels of drivers stopped at roadblocks show an appreciable decrement, especially among the lower BAC levels. A reduction in the number of charges for driving while under the influence of alcohol may also be observed (17, 18) but in other cases charges may increase (12). From roadside surveys, it appears that moderate drinkers are more affected than heavy drinkers by such legislation (22). A similar pattern of results is found in drivers involved in fatal accidents (16, 25). A marked decrease in the total number of road fatalities was observed in one country (27), along with lower BAC levels in those who died, but in other countries such favourable results have not been found (5).

---

[4] This does *not* seem to be a spurious finding due to greater likelihood of detection as the period of suspension increases.

[5] It might be, for instance, that those who are likely to commit the offence have characteristics that also lead to long jail terms.

However, these changes, even if they do occur, do not seem to be characterised by permanency. After some time, the number of prosecutions return to "seasonal norms" (18) and fatal accident rates slowly return to previous levels (16). Legislation regarding drinking and driving may form no exception to the more or less general phenomenon of "regression towards the pre-existing trend" that would seem to characterize accident rates some time after the introduction of any measure affecting safety (36).

There are several reasons that may account for this. The introduction of a new law is usually widely announced by the mass media. This may increase the general expectancy of the driving public that police enforcement has been stepped up appreciably. After some time people may find out that this is not so. Another potential factor is the reaction of the police and the courts. When prosecution rates go up, juries become more hesitant to convict, judges more reticent to impose heavy penalties and police officers in turn become less inclined to charge (9), the combined effect of these factors being a return to the 'normal', original base rates.

Following a legislative change involving an increase in prosecution rates and when penalties are made more severe, the courts are faced with a considerable dilemma. Severe punishment is usually reserved for those crimes that are viewed as highly immoral by the citizens of the country who – however indirectly – determine the content of the law and the nature and magnitude of punishment. However, the perceived immortality of an act would seem to depend very largely upon the social deviancy of the behaviour involved. Rapid increases in the frequency of prosecutions may lead to a reduction in the perceived deviancy of the act and hence provide a lesser justification for severe punitive actions. This is one factor that might explain the reduced tendency to convict or severely punish when charges are laid and it may also explain the reservation of heavy penalties for a few cases.

Consequently, in order to justify the severe penalties, either enforcement rates or the number of convictions have to be kept down. Out of this another dilemma arises. From an accident prevention point of view, a legal BAC limit of .05% or .08% may be too high, but if penalties are severe, these levels are too low to be truly enforceable and punishable. It may be argued that the current custom of severely penalising a small minority of the actual offenders, while the majority are undetected or unconvicted, constitutes an expedient, but basically unjustifiable, compromise that is bound to fail as a deterrent measure.

It is a truism, of course, that laws are more the result of events in the field of political forces than the social outcome of scientific evidence. Laws may well satisfy their political purposes without having a major effect upon the problem that they were apparently designed to solve.

Passing a law that condemns a very considerable proportion of the driving population does not seem to be capable of producing long term effects. A law that, strictly speaking, would have to be applied to as many as between 2 and 10-15% of all drivers using the roads at a particular time of day cannot be applied, either physically or morally. The behaviour in question is not sufficiently deviant to warrant continued public support for severe punishment for its occurrence. Passing a law that specifies a particular BAC level (e.g. 0.08 or .10%) as unacceptable does not take account of the observation that the likelihood of an individual of having an accident would seem to be monotonically dependent upon the BAC level of the individual. The apparent sudden rise beyond .05 or .08% could well be the result of an incomplete analysis of presently available data. Reanalysis of the now classic Grand Rapids data has indicated, for instance, that daily drinkers are almost as safe at a BAC of .09% as an abstainer or near-abstainer at a BAC .02%[6](19). For the individual it seems to be true, however, that the chances of having a road accident increase monotonically with the amount drunk, that is, there are no 'critical' thresholds such as .05 or .08%. This observation seems to be in agreement with laboratory findings that show that the degree of behavioural impairment in an individual at a given level of BAC depends very much upon his habitual drinking frequency. In light of this, it is not astonishing that habitually drinking drivers in an Austrian roadside survey (29) showed little belief in the statement that their driving capabilities were seriously impaired at BAC levels up to approximately .08%. Their own life experience would certainly not substantiate such a conclusion. Thus, it seems that we must face the following situation: if the critical legal BAC level is set relatively high, the calculated potential benefits for accident reduction will be correspondingly diminished. If, on the other hand, the critical BAC level were set relatively low, the law becomes unenforceable.

Even if this dilemma were satisfactorily resolved, other problems are likely to remain. A countermeasure succeeding in preventing alcoholics from drinking prior to their driving might not fully reduce their accidents to an average level because of the presumed proneness of alcoholics to have accidents even when sober (31, 33). Alternatively, a countermeasure that successfully reduces driving by alcoholics and problem drinkers after drinking but that does not affect their drinking, may have no beneficial effect upon the number of fatal accidents incurred by these individuals as pedestrians, or while they are driving during a hangover. Also their mortality due to accidents in other situations than traffic would not be favourably affected[7] (1). It is difficult to estimate the precise quantitative effects associated with these factors, but they should nevertheless be considered.

If countermeasures are introduced in a manner that leads to an emphatic pinpointing of alcohol as the main culprit in fatal and other serious accidents, large segments of the driving public (the 'sober drivers') might be led to believe that they have no major responsibility in the cause of accident avoidance. Blaming accidents on a single cause and the ensuing reaction of 'scape-goating' the intoxicated drivers as the most culpable in the road accident problem, might well result in reduced caution while driving on the part of large segments of the 'sober and generally law-abiding' citizens (23). Finally, if countermeasures effectively curtailed road accidents over a certain period of time, the resulting awareness of the driving public that 'the roads are no longer as dangerous as they used to be,' might lead to reduced caution in some drivers and consequently contribute some momentum to a regression to pre-existing trends of accident statistics (36).

Countermeasures have to be designed and executed in the light of what is presently known and whatever considerations emanate from the current state of information. As it is evident from this report that, in many respects, solid information is lacking on the direct and indirect or delayed effects of countermeasures implemented in the past, an experimental, explorative, and research-oriented approach is more warranted at the moment that the formulation of definitive, doctrinaire and inflexible verdicts in the domains of law, public education and in other areas in which countermeasures may be conceived.

---

[6] This and several other issues discussed in this paper are more elaborately documented in a report prepared by the present author: *Alcohol and Highway Safety, Part II, Alcohol and Traffic Accidents: A Review in Quest of Remedies.* Published by Transport Canada, Ottawa, 1974, and submitted to the NATO Committee on the Challenges of Modern Society.

[7] Alcoholics, matched with members of the general population, were found to meet with death 4.5 times more often in traffic, 16 times more often as a result of a fall, 30 times more often due to accidental poisoning, and 3 times more often due to other types of accidents.

RESEARCH INTO MASS COMMUNICATIONS EFFECTIVENESS

It would seem that the presently available 'academic' or 'experimental' literature provides us with little conclusive information on the use of mass communications as a means to reduce the rate of alcohol-involved accidents and specifically, how we can learn to make these communication procedures more effective. The problematic relationship between attitude, cognition and behaviour has already been mentioned. Moreover, it may well be that 'academic' psychology will continue to be of limited use in this respect, because of its insistence upon traditional laboratory experimentation as a means of data gathering.

The validity of laboratory experimentation is limited by the following factors:

> *First, of all possible independent variables that influence behaviour in any practical situation, a laboratory experiment selects only a few for test. As a result, hidden or unsuspected interactions in real-life may easily nullify, or even reverse, conclusions arrived at in the laboratory. Second, variables always change when they are brought into the laboratory. Third, the effect of controlling extraneous or irrelevant variables in the laboratory is to increase the precision of an experiment but at the risk of discovering effects so small that they are of no practical importance. Fourth, the dependent variables (or criteria) used in laboratory experiments are variables of convenience. Rarely are they selected for their relevance to some practical situation.* (7)

To this quotation, the following considerations may be added: Fifth, laboratory experiments almost invariably make use of volunteers, who are known to differ from the general population in demographic as well as personality characteristics (26). Sixth, most measurement techniques are reactive, *i.e.*, they bring about a change in the behaviour under investigation (15) and interfere with a proper assessment of the effect of independent variables. Seventh, laboratory studies make a rigorous distinction between independent and dependent variables that may find no realistic counterpart in real life. Exposure to a communication, for instance, is a behaviour normally under the control of the subject, not the experimenter. Laboratory studies on the effect of alcohol on behaviour involve amounts of drinking determined by the experimenter, not by the subject. To the laboratory experimenter, this would seem entirely appropriate, but in real life it may well be that the subject's decision to drink to a state of inebriation derives from the same causes as his subsequent decision to drive, and to drive in a particular manner. Alcohol does not 'cause' accidents in the same sense as heat causes ice to melt. Some persons may be poor drivers for the same reasons that they drink too much. Thus both drinking and dangerous driving may be viewed as dependent variables and to construe the former as an independent variable takes no account of the natural history of behaviour. The logic of laboratory experimental design in many cases has no ecological validity.

This rather heavy elaboration may perhaps be summed up in a metaphoric story as told by a grand old man among Belgian psychologists, Professor Nuttin. A psychology professor who is searching all over the floor of his laboratory is surprised by a student who comes in late at night. The student asks him what he is looking for and the professor tells him he has lost his gloves in the park. But, so the student says, why don't you look in the park if you lost your gloves there, to which the professor answers that it is dark in the park and in the lab at least there is light.

INCREASING COUNTERMEASURE EFFECTIVENESS

I am inclined to infer from this type of reasoning that a truly scientific knowledge of how to influence behaviour through mass communications can best be derived from operational research involving field experimentation and field studies. In other words, by conducting and evaluating mass communication campaigns we will eventually learn how to do it effectively. Past research already has identified a number of principles that would seem to differentiate the successful from the unsuccessful publicity programmes. Some of these principles are instructiveness, immediacy and personal relevance of the message, the conspicuousness of the target behaviour and the deliberate enhancement of social imitation among the target audience. These principles have been described elsewhere in more detail (35, 36, 37).

For this knowledge to be further developed a number of conditions must be fulfilled. First, no major campaign should go unaccompanied by serious and thorough research into its effects. Second, the evaluative research should be conducted in agreement with the requirements of good experimental design including adequate control data and nonreactive measurement. Lack of adherence to rigorous research methods has weakened the conclusiveness of the results of many alcohol campaigns carried out so far. To work in the field rather than in the laboratory is no excuse for sloppiness.

What has been said about the need for field experimentation in the domain of mass communication also holds for research into the effects of alcohol upon actual driver behaviour. Laboratory research can indeed identify potential sources of variances but this is also the best it can do. It cannot measure the extent to which these factors actually contribute to accident causation. The few field experiments on the effect of high BAC levels on driving in real traffic have produced results that only marginally corroborate what has emanated from laboratory investigations[8] (30). We do know that a functional relationship between alcohol and accident likelihood exists but why this is so has so far remained largely unknown, because few realistic studies have focussed on the question of how greater accident likelihood is mediated through the consumption of alcohol. No rational development of countermeasures can occur without this knowledge.

Another requirement for progress, so it would seem, is that we refrain from the rather fruitless battle about the alleged superiority of either legislation, mass education or physical road and vehicle modifications for the promotion of safety. Recent experience following Australia's legislation which made the wearing of seat belts mandatory is a case in point. This legislation was passed, among other things so it seems, because of an (erroneous) impression that mass education would not produce any results. Following legislation, seat belt wearing did indeed increase, but the beneficial effect upon accident survival rates, according to my calculations, amounted to about one half of what could have been expected on the basis of earlier established relationships between seat belt wearing and crash survival (32). This may be due to the fact that only about 11 per cent of drivers in the State of Victoria who use their seatbelts appear to buckle them adequately. As a consequence, the authorities have decided that a mass media campaign is necessary to bring about proper wearing habits! An integrated legislative-educational-ergonomic effort might well have been preferable.

---

[8] The author had subjects drink to BAC levels of approximately .13% who drove in real traffic in a West Germany city in dual control cars. Driver errors made under sober and intoxicated conditions were observed and compared. Perceptual and judgemental driving skills were not significantly affected, but significant differences in tracking performance were established.

I can only speculate on what form such a comprehensive approach in the area of drinking and driving might take. The following points could perhaps be considered. First, drinking is usually not a solitary but a group activity. By implication, this behaviour is not only a function of the traits of the individual but of the dynamics of social interaction. Yet the law makes the drinker responsible for his behaviour as an individual, as if he were an autonomous entity. It might be argued that the law should be designed so as to address itself more to the patterns of human interaction in which drinking takes place. One possibility in this direction might be a greater use of concepts such as accessory to the act and co-responsibility of others for the act of driving after drinking.

Second, the law will fail to have special deterrent effects unless the punishable BAC level is set at a high level that rarely occurs in the driving population. Punishment should be fast and in accordance with public opinions of justice (2). However, the potential contribution to accident reduction to be made through special deterrence remains small even when maximised.

Third, the general deterrent effect of the law seems to depend largely upon the level of perceived enforcement risk. Should we therefore say the more enforcement the better? I think not, because of the undesirable side-effects that may follow. If many drivers are stopped by police, a negative attitude towards the police and the authorities in general might well ensue. Some studies seem to indicate that the many unpleasant contacts between public and police, that have been a consequence of the general use of the automobile, may have contributed to hostility towards the police and decrease in respect for the law of the land (9). In other words, what may be gained in road safety may be lost elsewhere.

Fourth, mass communication theory suggests among other things that there should be more immediacy between the message and relevant situation. Accordingly, bottles and other containers of alcoholic beverages may be provided with a warning saying: the chances of having an accident increase with the amount drunk. Similarly, warning messages may be placed in conspicuous places in bars, restaurants and the like.

Fifth, in agreement with the principle of instructiveness in effective mass communication, any law regarding drinking and driving should be publicized in a concrete, unambiguous manner that informs drivers of what amounts of drinking result in what levels of BAC and thus should be avoided.

Sixth, road collisions are rare events in the life of any particular individual and they therefore give him little opportunity to learn to avoid them. A person might, however, learn from road collisions that had happened to others if the relevant information of contributing factors were made available. Ideally, therefore, accident reports in newspapers, radio and television – reports that enjoy a high degree of public attention – should be presented in such a way as to maximize the opportunity for learning. All commercial advertising and related publicity should be made so that they do not interfere with the promotion of safety-oriented behaviours.

Seventh, the general public and the law makers should be exposed to whatever is scientifically known about accident causation in order to reduce the likelihood of the introduction of laws and other countermeasures that may not be effective.

Good laws and good mass communication are precious instruments in a society that attempts to optimize its functioning. Injudicious use of these regulatory and behaviour shaping instruments can only help to erode their potential beneficial effect in the future.

REFERENCES

1. Brenner, B., Alcoholism and Fatal Accidents. *Quarterly Journal of Studies on Alcohol,* 28, 517-528 (1967).
2. Brown, I. D. and Copeman, K., *Drivers' Attitudes to the Seriousness of Road Traffic Offences Considered in Relation to the Design of Sanctions.* Paper presented at the First International Conference on Driver Behaviour, Zurich, Switzerland, October 8-12, 1973.
3. Buikhuizen, W., *Strafmaat en recidivisme* (Size of penalty and recidivism). Chapter 8 in Buikhuizen, W. (Ed.), Alcohol en Verkeer (Alcohol and Traffic), Meppel, Holland, Boom en Zoon, 1968.
4. Buikhuizen, W. and Van Weringh, J., *Voorspellen van recidivisme* (The prediction of recidivism). Chapter 7 in Buikhuizen, W. (Ed.), Alcohol en Verkeer (Alcohol and Traffic), Meppel, Holland, Boom en Zoon, 1968.
5. Carr, B. R., Goldberg, H., Farbar, C.M.C., The Canadian Breathalizer Legislation: An Inferential Evaluation. Ministry of Transport, Ottawa, 1973.
6. Campbell, B. J., *Problems in the Attempt to Define and Predict Who Will Be the "Accident Repeater".* Paper presented at the First International Conference on Driver Behaviour, Zurich, Switzerland, October 8-12, 1973.
7. Chapanis, A., The Relevance of Laboratory Studies to Practical Situations. *Ergonomics,* **10**, 557-577 (1967).
8. Coppin, R. S. and Van Oldenbeek, G., *Driving Under Suspension and Revocation.* Report No. 18. Research and Statistics Section, Division of Administration, California Department of Motor Vehicles, Sacramento, January, 1965.
9. Cressey, D. R., *Law, Order and the Motorist.* Paper presented at the Bristol Seminar on the Sociology of the Police, February 25-28, 1971.
10. Doob, A. N. and Gross, A. E., Status of Frustrator as Inhibitor of Horn-Honking Responses. *Journal of Social Psychology*, 76, 213-218 (1968).
11. The Edmonton Study; The Impact of a Drinking Driving Campaign. Published by Transport Canada, Road Safety, Ottawa, 1973.
12. Farmer, P. J., *Review and Evaluation of Legislative and Enforcement Programmes.* Proceedings of the Conference on Medical, Human, and Related Factors Causing Traffic Accidents, Including Alcohol and Drugs. Montreal, Canada, May 30-31, 1972.
13. Fhaner, G. and Hane, M., *Seat Belts: The Importance of Situational Factors.* Report No. 22, The National Swedish Road Safety Office, University of Uppsala, 1972.
14. Gibb, D. G.,*.05 Blood Alcohol Awareness Campaign.* Paper presented at the First International Conference on Driver Behaviour, Zurich, Switzerland, October 8-12, 1973.
15. Hartley, J. Improving Publicity: A Suggestion. *Visual Education*, 29-30, February, 1971.
16. Havard, J. D., *Value and Deficiencies of Studies on BAC's Among Dead and Injured.* Proceedings of the Conference on Medical, Human, and Related Factors Causing Traffic Accidents, Including Alcohol and Drugs. Montreal, Canada, May 30-31, 1972.
17. Hooftman, J. C., Het strafrecht en het rijden onder invloed (Criminal law and driving under the influence). In Buikhuisen, W. (Ed.), *Alcohol en Verkeer (Alcohol and Traffic)*, Meppel, Holland, Boom en Zoon, 1968, chapter 9.
18. Hooper, A., Crubside Licence Suspension, *Criminal Law Quarterly (Canada)*, **10**, 22-25, (1967-68).
19. Hurst, P. M., *Blood Alcohol and Highway Crashes: A Selective Review of Epidemiological Findings.* Institute for Research, State College, Pennsylvania, October, 1972.
20. Kiesler, C. A., Collins, B. E., and Miller, N. *Attitude Change: A Critical Analysis of Theoretical Approaches*, Wiley and Sons, New York, 1969.

21. Klette, H., *Om social kontroll av grove trafikbrottslighet* (On legal control of serious traffic offences). Department of Law and Sociology, University of Lund, Sweden, 1972.

22. L'Hoste, J., *Quelques résultats de recherches menées en France à propos de l'impregnation éthylique des conducteurs.* Proceedings of the Conference on Medical, Human, and Related Factors Causing Traffic Accidents, Including Alcohol and Drugs. Montreal, Canada, May 30-31, 1972.

23. Naisbitt, J., The Great Holiday Massacre: A Study of Impact, *Traffic Safety*, 58, 12-15, 36, 48-49 (1961).

24. Pedersen, T. O., *Oppmerksomhetsverdi og budskapsformidling av fem trafikksikerhet* (Attitudinal and Informational Value of Five Traffic Safety Advertisements). Report published by Transportoekonomisk Institutt, Stasjonsveien 4, Oslo 3, Norway, 1971.

25. Perrine, M. W., *Collection of Baseline Data on Effect of Alcohol Consumption on Traffic Accidents.* Proceedings of the Conference on Medical, Human, and Related Factors Causing Traffic Accidents, Including Alcohol and Drugs. Montreal, Canada, May 30-31, 1972.

26. Rosenthal, R., The Volunteer Subject. In Badia, P., Haber, A., and Runyon, R. P. (Eds.) *Research Problems in Psychology.* Reading Massachusetts, Addison-Wesley, 1970. Chapter 2.

27. Ross, H. L. Law, Science and Accidents: The British Road Safety Act of 1967. *Journal of Legal Studies*, 2, 1-78, (1972).

28. San Antonio Alcohol Safety Action Project. *Annual Report for 1973, Section II-A-7, Analytic Study #7.* An Analysis of Public Information and Education Activity and an In-Depth Countermeasure Report for PI and E Countermeasures. Southwest Research Institute, San Antonio, Texas, 1974.

29. Schmidt, L. *Effektivitaetskontrolle der Alkohol-Schwerpunktaktion 1973.* Kuratorium fuer Verkehrssicherheit, Vienna, 1974.

30. Schneider, W., *Rijden onder de invloed: een experiment* (Driving under the influence: an experiment). In Buikhuizen, W. (Ed.), Alcohol en Verkeer (Alcohol and Traffic), Meppel, Holland, Boom en Zoon, 1968. Chapter 5.

31. Smart, R. G., Are Alcoholics' Accidents Due Solely to Heavy Drinking? *Journal of Safety Research*, 1, 170-173 (1969).

32. Traffic Injury Research Foundation. Proceedings of the Annual Conference. Ottawa, May 23-24, 1974 (in press).

33. Waller, J. A., Impaired Driving and Alcoholism: Personality or Pharmacologic Effect. *Journal of Safety Research*, 1, 174 (1969).

34. Waller, J. A. and Worden, K. J., *Application of Baseline Data for Public Education About Alcohol and Highway Safety.* Paper presented at the Conference on Evaluation of ASAP Projects. U.S. Dept. of Transport, Bethesda, Maryland, September, 1973.

35. Wilde, G.J.S., L'Hoste, J., Sheppard, D., and Wind, G., *Road Safety Campaigns; Design and Evaluation: The Use of Mass Communications for the Modification of Road User Behaviour.* OECD Publications, Paris, 1971.

36. Wilde, G.J.S., *General Survey of Efficiency and Effectiveness of Road Safety Campaigns: Achievements and Challenges.* Proceedings of the International Congress at the Occasion of the 40th Anniversary of the Dutch Road Safety Association. The Hague, October 19-20, 1972.

37. Wilde, G.J.S., Cake, L. J., and LeBrasseur, R., *Mass Media Safety Campaigns: An Annotated Bibliography of Recent Developments 1970-1973.* Report prepared for the United States Department of Transportation, National Highway Traffic Safety Administration, May, 1974.

The Investigation of Blood Alcohol Levels in 967 Road Accident Fatalities

Donald W. Hossack[1]

This paper deals with the relationship between alcohol and road fatalities in the State of Victoria during the period 1970-1973. If the problem of alcohol is related to the per capita consumption of alcohol, Australia has the greatest problem of all the English speaking countries. The pattern of the problem appears to be the short term effect of explosive drinking over a few hours in the evening and at week-ends. Most workers now accept that the case against alcohol as a major factor in road accidents has been proved.

This series deals with the blood alcohol levels estimated on 967 post-mortems personally conducted on road accident victims. I would like to consider the report in two parts in order to see if there were any significant changes in the blood alcohol picture in road fatalities in the second series after a fairly low-key period of media education of the driving public.

In the first series of post-mortems over a period from June 1970 to May 1971 I performed 400 post-mortems. The breakdown of the different categories is shown in Figure 1. Of 171 drivers killed, 103 (60%) had ingested alcohol. This is a conservative figure as 13 were not tested due to prior hospitalisation.

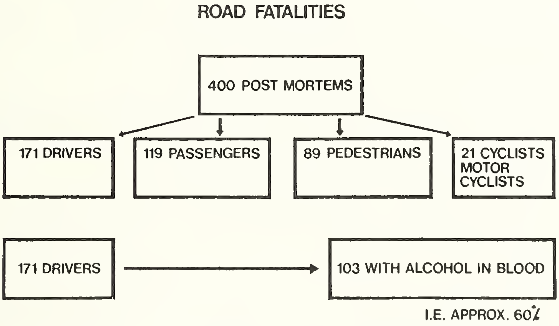


Figure 1 *Breakdown of 400 fatal road accidents.*

---

[1] Consultant Surgeon to the Coroner, 70 Collins Street, Melbourne 3000, Victoria, Australia.

Figure 2 shows the blood alcohol levels in the 103 drivers killed. In the State of Victoria driving with a blood alcohol level above 50 mg/100 ml of blood is illegal since evidence indicates that driving skill rapidly deteriorates after this level is reached. In this series of drivers, 50% of the total 171 killed had blood alcohols greater than 100 mg/100 ml of blood. Borkenstein (1) and his fellow workers showed that a level of 160 mg/100 ml of blood was likely to increase the risk of accident to 20 times that of a non-drinker. It will be seen that of these 171 drivers, 38% had blood alcohol levels well above this point.

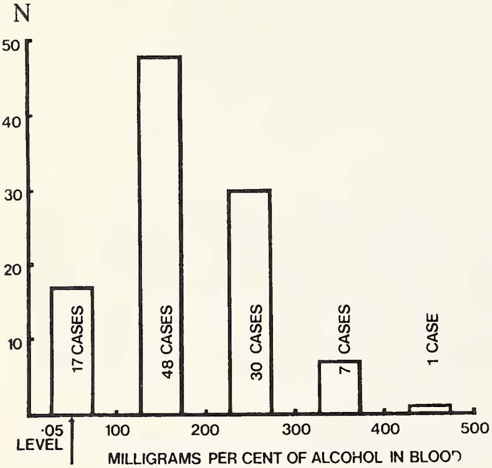


Figure 2 *Blood alcohol levels in 103 drivers killed in road accidents.*

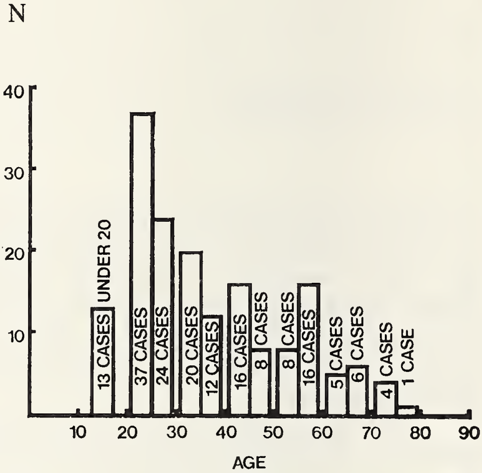


Figure 3 *Ages of 171 drivers killed in road accidents.*

Work done in this field of alcoholism indicates that a blood alcohol level greater than 150 mg/100 ml of blood is suggestive of a drinking problem. Therefore, in this series of 171 killed drivers, 38% were possible problem drinkers.

Figure 3 shows the age of killed drivers and it will be noted that 29% of these were under 25 years of age. It was also found that of the under 25-year-old drivers killed, 78% had a blood alcohol above the legal limit. If 150 mg/100 ml of blood indicates a possible problem drinker, then 58% of drivers under 25 years of age were possible problem drinkers. In the drivers killed in this series, 92% were males and few only of the women drivers had blood alcohol levels above the legal limit.

Analysis of the blood in 119 passengers killed revealed approximately 50% had blood alcohol levels resembling those of the drivers.

Pedestrian deaths revealed approximately 54% with very high blood alcohol levels. It was noted that 69% of pedestrians killed were males and mostly in their sixties and seventies. Alcohol did not appear to be an important factor in killed cyclists or motor cyclists.

The second part of this report covers 567 post-mortems on fatal accidents over the period January 1972 to June 1973 (Figure 4).

Of the 273 killed drivers, 22 had been hospitalised and were not analysed. Of the 251 cases analysed, 46.6% had blood alcohols in excess of the legal limit of 50 mg/100 ml. Figure 5 shows the actual blood alcohol levels in these 127 killed drivers. As in the first series, very few female drivers had blood alcohol levels of a significant degree.

The age distribution of the 273 killed drivers is shown in Figure 6. One hundred and twenty-eight (46.9%) were under 30 years of age. Of 85 killed drivers who were 25 years or younger, 49 (57.7%) had blood alcohol levels greater than 50 mg/100 ml.

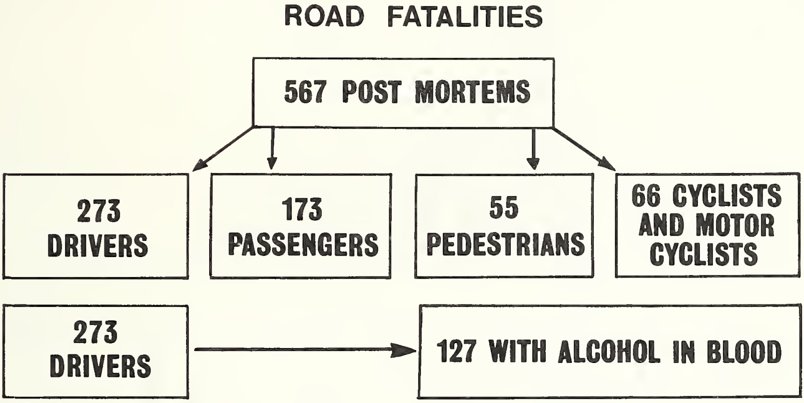


Figure 4 *Breakdown of 567 fatalities – January 1972 to June 1973.*

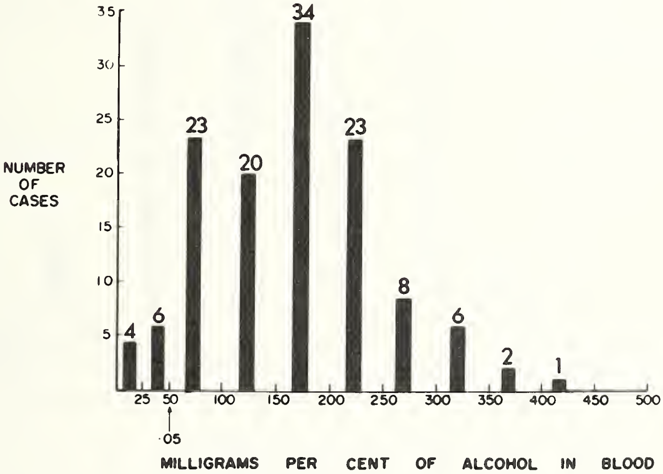


Figure 5 *Blood alcohol levels of 127 drivers who had ingested alcohol and were killed between January 1972 and June 1973.*

Figure 7 shows the actual blood alcohol levels in 52 drivers who were 25 years and under. Thus, in this series of 251 killed drivers tested, approximately 27% had blood alcohol levels above 150 mg/100 ml suggesting a possible drinking problem. It was found that approximately 30% of killed drivers under 25 years of age would also have blood alcohol levels suggestive of a drinking problem.

In the other categories of pedestrians, passengers, cyclists and motor cyclists, the pattern of blood alcohol levels was similar to the first series.

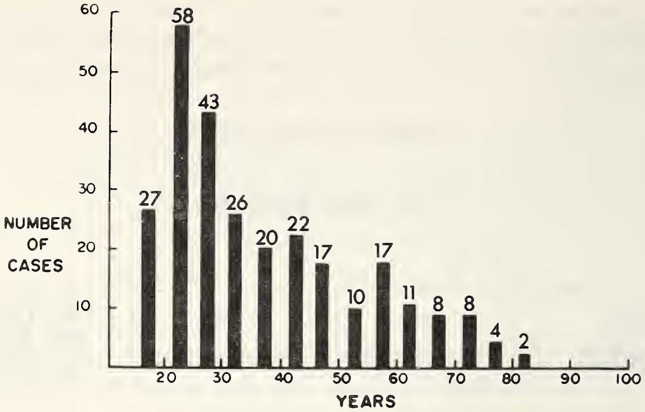


Figure 6 *Age distribution of 274 drivers killed between January 1972 and June 1973.*

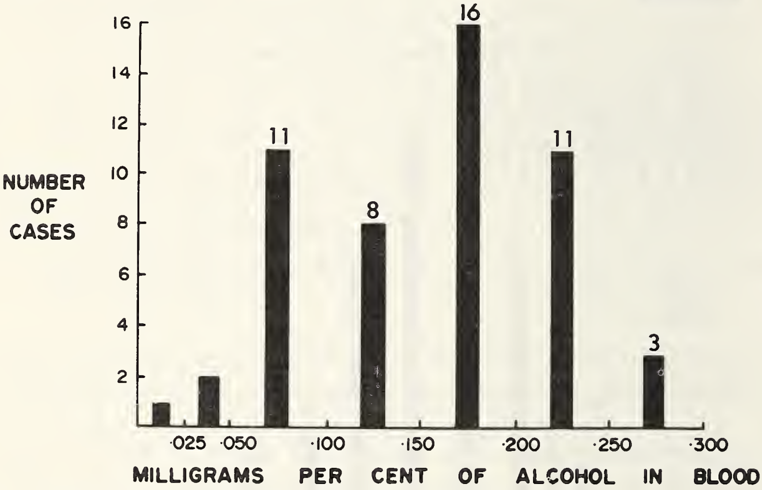


Figure 7 *Blood alcohol levels in 52 drivers aged 25 years and under.*

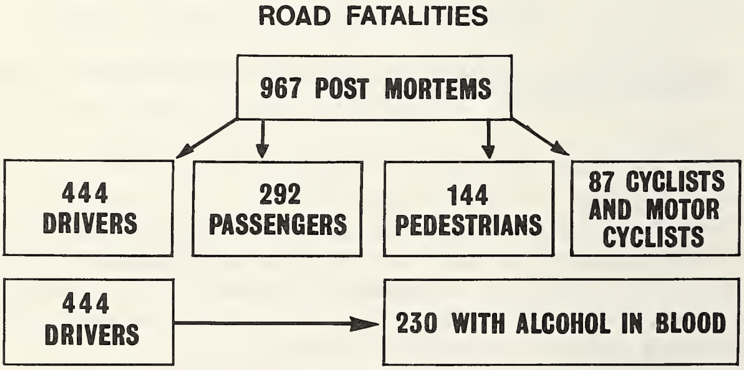


Figure 8 *Breakdown of 967 fatalities – June 1970 to June 1973.*

Figure 8 shows the breakdown of 967 post-mortems. Of the 444 killed drivers, 409 were tested for alcohol and 230 (51.8%) had ingested alcohol. Of these 181 (44%) had blood alcohol levels above 100 mg/100 ml. Actual blood alcohol distribution in the 230 drivers, of the total 444, who had ingested alcohol is shown in Figure 9. Of the 444 drivers killed, 203 or 45% were 30 years old or younger (Figure 10).

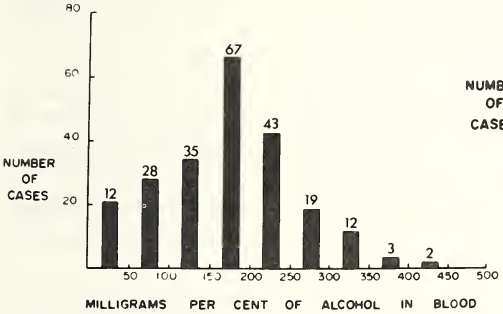


Figure 9 *Blood alcohol levels in the 230 drivers who had ingested alcohol from the combined series of 444 drivers.*

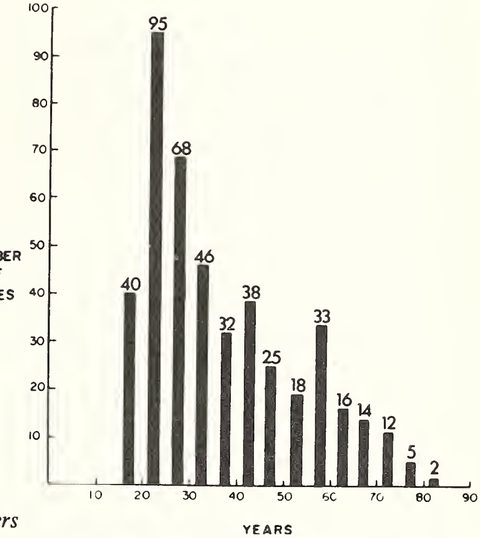


Figure 10 *Age distribution of 444 drivers killed in the combined series.*

DISCUSSION

If the number of killed drivers in each category of blood alcohol level is expressed as a percentage of the total number of drivers killed in each of the first and second series, it will be seen that there is no significant change in the blood alcohol levels in either group despite the low-key education program in the media.

However, there has been a significant reduction in the death toll and accidents involving casualties in the State of Victoria over the past 3-4 years – a pattern which is not reflected throughout Australia.

From a steadily rising casualty and death toll up to 1970, when the accident casualty rate was 131.9 per 10,000 vehicles registered or 488 casualties per 100,000 of population, the casualties dropped steadily in 1971 and 1972. In 1973 the rate per 10,000 vehicles registered was 96.1 and the casualties per 100,000 of population down to 402.7.

The death rate is equally surprising in that it falls from 8.1 per 10,000 vehicles registered in 1970 to 6.2 per 10,000 vehicles registered in 1973. This was also reflected in the fall of deaths from 30.7 per 100,000 of population in 1970 to 26 per 100,000 in 1973.

It would be tempting to attribute this improvement to the education program aimed at the drinking driver. However, I think the improvement can be explained by the introduction of compulsory seat-belt legislation. The Royal Australasian College of Surgeons urged the Government to introduce such legislation and this was done in December of 1970. Apart from the reduction in death since then, there has been a notable decline in the number of paraplegics in the State.

CONCLUSION

It is becoming apparent, that if our version of a tribal system is to survive, it will be accompanied by increasing restrictions of personal liberty in relationship to both the environment and to the other members of the community. Such restrictions, regrettably, are required when the community does not voluntarily follow advice for their own safety as well as the safety of the community at large. Evidence now indicates that the drunk driver is far more responsible for the carnage on the roads than are other members of the community. To support this statement, the Department of Transport's National Highway Safety Bureau reported to the United States Congress that 53% of drivers killed had blood alcohol levels greater than 100 mg/100 ml of blood. This compared with 2% of a similar driving population not involved in accidents. Similar results were found by McCarroll and Haddon in New York City in 1962 (2). Over the past year in Melbourne 54 drivers who collapsed and died whilst driving their cars were found to have significant blood alcohol readings in less than 5% compared with nearly 50% in drivers killed in accidents.

The Trauma Committee of the Royal Australasian College of Surgeons has advised the Government to introduce legislation for the compulsory wearing of seat belts with outstanding success. It has now persuaded the Government to introduce new legislation, so that every victim of an accident over the age of 15 years admitted to the casualty department of hospitals after an accident, has a blood alcohol estimation. The purpose of this is to detect the drunken driver, to manage the patient more thoroughly and to detect those persons with alcohol problems and advise them on proper treatment. In 1974 the Government proposes to introduce legislation to allow traffic police to stop any car at any time and request a puff-bag test to estimate blood alcohol levels.

These new areas of legislation, it is hoped, will, along with seat belts and a 60 mile per hour maximum speed, reduce the carnage on the road even more. It has been found that the public will accept these restrictions willingly if sufficient preparation from respected and authoritative bodies precedes their introduction.

REFERENCES

1. Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B. and Zylman, R. The Role of the Drinking Driver. In *Traffic Accidents*, Dale, A. (ed), Department of Police Administration, Indiana University, Bloomington, Indiana, 1964.

2. McCarroll, J. R. and Haddon, W., A Controlled Study of Fatal Automobile Accidents in New York City, *Journal of Chronic Diseases*, **15**, 811 (1962).

The Edmonton Study

A Pilot Project To Demonstrate The Effectiveness Of A Public Information Campaign On The Subject Of Drinking And Driving

Philip J. Farmer[1]

In 1972 in Canada 6,221 persons lost their lives and 215,000 were injured in traffic accidents (1). Statistics show that 55.5 per cent of the drivers killed in fatal crashes had been drinking and that 80 per cent of these had blood alcohol levels above 0.10 per cent (4). Studies also indicate that between 35 and 40 per cent of the drivers convicted of impaired driving may have a drinking problem.

In Canada, impaired driving is an offence under the Criminal Code of Canada.

> Section 234 – Impaired driving is an offence even if a driver's blood alcohol content (BAC) is less than .08 per cent.
>
> Section 235(1) – Breath tests for blood alcohol are compulsory when demanded by a peace officer.
>
> Section 235(2) – It is an offence to refuse to take a breath test for blood alcohol.
>
> Section 236 – It is an offence to have care or control of a motor vehicle with a blood alcohol content in excess of .08 per cent.

Surveys indicate that about 80 per cent of adult Canadians drink beverage alcohol, at least occasionally (2). In Canada, driving after drinking is not considered deviant behaviour and the driving public is largely unaware of the dangers to themselves and to others associated with driving while impaired by beverage alcohol. The staggering cost of traffic accidents is only dimly perceived by many drivers and the tragic consequences always happen to 'the other guy' in the minds of most motorists.

To the Canada Safety Council these facts suggested an urgent need for a continuing national public information program on the subject of drinking and driving. As a prerequisite to a national campaign, the Council decided to carry out a pilot project and to measure its effectiveness.

THE STUDY (3)

The campaign in Edmonton was planned and conducted by the Canada Safety Council in co-operation with the Edmonton and Alberta Safety Councils. The Canada Safety Council hired an engineering counsultant to conduct before and after roadside surveys.

---

[1] Executive Director, Canada Safety Council, Ottawa, Ontario, Canada

The Ministry of Transport supplied the research methodology and evaluated the data collected through the roadside surveys.

Campaign Objectives

To conduct a public information campaign for responsible drinking and driving, aimed at changing knowledge, attitude and behaviour by: (a) alerting the public to the seriousness of the traffic accident problem related to the irresponsible use of beverage alcohol; (b) outlining the action of beverage alcohol and the dangers when related to the driving task; (c) reviewing the penalties for impaired driving and (d) suggesting changes in drinking-driving behaviour.

The ultimate objective of the campaign was to effect a change in drinking-driving behaviour, specifically to have motorists drive less after drinking and to not drive at all after heavy drinking, *i.e.*, when intoxicated.

Target Audience

The target audience was the social drinker. While in the past many programs have been aimed at the problem drinker, the Edmonton campaign was directed to the social drinker because the majority of people who use beverage alcohols and drive are social drinkers; social drinkers would not relate to a campaign aimed at the problem drinker; and, while problem drinkers are unlikely to be influenced by a public information campaign, their behaviour may be influenced by family, friends, doctors or social workers.

Campaign Theme – "If You Drive After Drinking. . ."

The theme was chosen as one which would relate to the majority of drivers. The public were given factual information relating to the problem and suggestions as to how to avoid alcohol-related accidents.

Project Location

The City of Edmonton was chosen as the site for the pilot project and Calgary as the control city. Both cities are about the same size (400,000 population), have the same socioeconomic background, have their own media of mass communications (newspaper, radio and TV stations), police forces and active safety councils. The cities are about 200 miles apart and to a great extent information spillover was avoided.

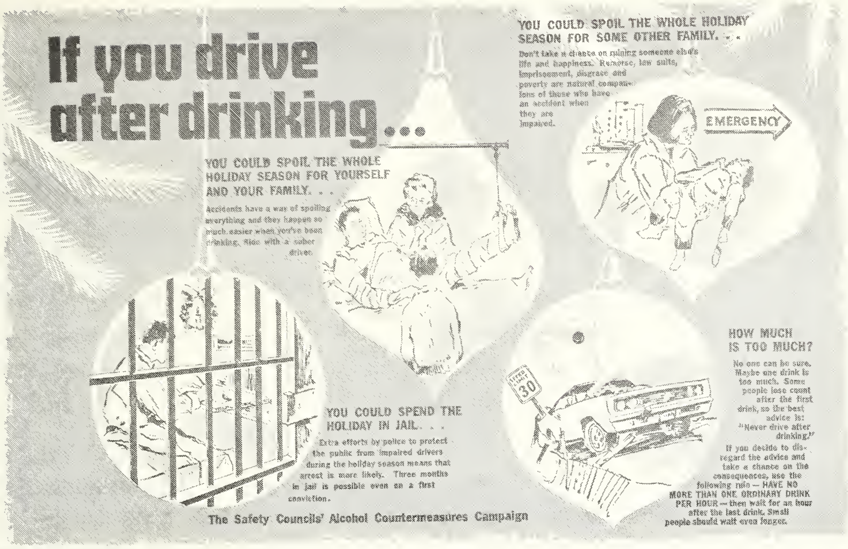
Campaign Timing

The Edmonton campaign was conducted for one month from December 6, 1971, to January 5, 1972. This time of year is considered to be a prime time for social drinking and a time when many people drive after drinking.

Campaign Features

The following is a brief description of the activities and materials used in Edmonton:

Place Mats. – 50,000 were distributed to hotels, restaurants and service clubs (Fig. 1).



If you drive after drinking...

YOU COULD SPOIL THE WHOLE HOLIDAY SEASON FOR YOURSELF AND YOUR FAMILY. . .

Accidents have a way of spoiling everything and they happen so much easier when you've been drinking. Ride with a sober driver.

YOU COULD SPOIL THE WHOLE HOLIDAY SEASON FOR SOME OTHER FAMILY. . .

Don't take a chance on ruining someone else's life and happiness. Remorse, law suits, imprisonment, disgrace and poverty are natural companions of those who have an accident when they are impaired.

YOU COULD SPEND THE HOLIDAY IN JAIL. . .

Extra efforts by police to protect the public from impaired drivers during the holiday season means that arrest is more likely. Three months in jail is possible even on a first conviction.

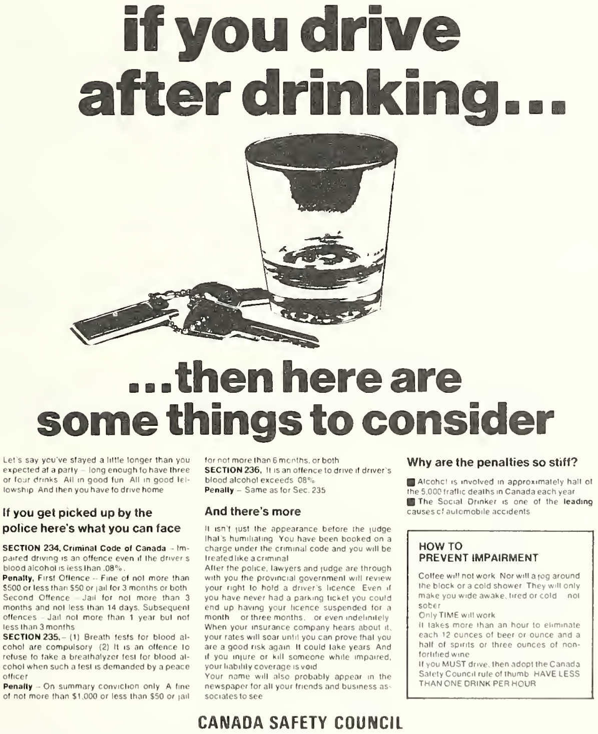
HOW MUCH IS TOO MUCH?

No one can be sure. Maybe one drink is too much. Some people lose count after the first drink, so the best advice is: "Never drive after drinking."

If you decide to disregard the advice and take a chance on the consequences, use the following rule — HAVE NO MORE THAN ONE ORDINARY DRINK PER HOUR — then wait for an hour after the last drink. Small people should wait even longer.

The Safety Councils' Alcohol Countermeasures Campaign

Figure 1 *Place mat distributed to hotels, restaurants and service clubs.*



if you drive after drinking...

...then here are some things to consider

Let's say you've stayed a little longer than you expected at a party – long enough to have three or four drinks All in good fun All in good fellowship And then you have to drive home

If you get picked up by the police here's what you can face

SECTION 234, Criminal Code of Canada – Impaired driving is an offence even if the driver's blood alcohol is less than .08%.
Penalty, First Offence – Fine of not more than $500 or less than $50 or jail for 3 months or both
Second Offence – Jail for not more than 3 months and not less than 14 days. Subsequent offences – Jail not more than 1 year but not less than 3 months
SECTION 235, – (1) Breath tests for blood alcohol are compulsory (2) It is an offence to refuse to take a breathalyzer test for blood alcohol when such a test is demanded by a peace officer
Penalty – On summary conviction only A fine of not more than $1,000 or less than $50 or jail for not more than 6 months, or both
SECTION 236, It is an offence to drive if driver's blood alcohol exceeds .08%
Penalty – Same as for Sec. 235

And there's more

It isn't just the appearance before the judge that's humiliating You have been booked on a charge under the criminal code and you will be treated like a criminal
After the police, lawyers and judge are through with you the provincial government will review your right to hold a driver's licence Even if you have never had a parking ticket you could end up having your licence suspended for a month or three months. or even indefinitely
When your insurance company hears about it, your rates will soar until you can prove that you are a good risk again It could take years And if you injure or kill someone while impaired, your liability coverage is void
Your name will also probably appear in the newspaper for all your friends and business associates to see

Why are the penalties so stiff?

■ Alcohol is involved in approximately half of the 5,000 traffic deaths in Canada each year
■ The Social Drinker is one of the leading causes of automobile accidents

HOW TO PREVENT IMPAIRMENT

Coffee will not work Nor will a jog around the block or a cold shower They will only make you wide awake, tired or cold – not sober
Only TIME will work
It takes more than an hour to eliminate each 12 ounces of beer or ounce and a half of spirits or three ounces of non-fortified wine
If you MUST drive, then adopt the Canada Safety Council rule of thumb HAVE LESS THAN ONE DRINK PER HOUR

CANADA SAFETY COUNCIL

Figure 2 *Poster distributed for window displays.*

Posters (17" x 23"). – 1,000 distributed for window displays.

Posters (8½" x 11"). – 50,000 distributed to government, business and industry. (Fig. 2).

Pamphlet (8 page). – 50,000, of which 40,000 were distributed to householders, the balance to meetings and industry.

Silk Screened Posters. – 150 mounted on frames and fastened to power poles on main traffic arteries by the Traffic Engineering Department.

Payroll Stuffers. – 50,000 used with provincial and city government and business payrolls.

Outdoor Billboards. – 22 lighted panels in good locations on main traffic arteries.

Radio Tapes. – Seven different tapes to each radio station 30-Second TV Film Clip. One to each TV station.

Press Kit. – To all newspapers, radio and TV stations included press releases, feature stories, statistics, spot announcements, etc.

Essay Contest. – An essay contest on the topic "If You Drive After Drinking" was conducted in 11 Junior High Schools. Prizes were offered.

Speakers. – Speakers visited service clubs and schools.

Special Meetings. – These included meetings with community organizations, pre-campaign briefing for the news media, formal opening of the campaign and luncheon meeting with senior executives from the communications media.

A Breathalyzer Reception was held for media people with their own programs or columns. Each person kept a private record of the cumulative number of drinks, the time, and blood alcohol level as measured by the Breathalyzer with repeated checks throughout the course of the reception. Many were amazed when they learned the number of drinks required for them to reach the .08 legal limit and indicated that they would not attempt to drive under the circumstances. The reception greatly improved understanding and generated a good deal of comment in the media as a result.

Santa Claus met the press and related his concern for the children of the father who may not make it home on Christmas Eve.

The Old Man With The Scythe, a talented entertainer made up as father time, visited radio and TV stations and the newspapers.

Edmonton Police Department. – In line with their policy of level enforcement, the Edmonton Police Department did not carry out special programs or increase enforcement levels during the campaign.

The campaign news and information items which related to the questions asked in the roadside survey, were not given special emphasis in the campaign.

Control City – Calgary

The control city of Calgary was subjected to its normal December traffic safety campaign.

The Calgary Safety Council conducted the annual Safe Driving Week Campaign. The Alberta Motor Association carried out their annual "Police Yourself" campaign aimed at drinking and driving. The Calgary Police Department conducted their annual program aimed at drinking drivers.

CAMPAIGN EVALUATION

Introduction

Typical evaluations of this type in the past have employed questionnaires in an attempt to measure changes in attitudes, knowledge, or both. The problem with this technique has been that a change in either knowledge or attitudes does not necessarily mean that there will be a concomitant change in the behaviour which is to be manipulated. In this particular case, the purpose of the campaign was to reduce the proportion of the population driving while impaired by beverage alcohol. It was therefore decided to measure the distribution of blood alcohol contents in a randomly selected sample of drivers. At the same time, questions were asked which tested the level of knowledge of subjects about various points which had been emphasized in the campaign, and the drivers' attitudes toward present drinking-driving laws.

Of primary interest in this study were those drivers who were found to be over the legal blood alcohol limit. Since there are relatively few of these, it was decided to employ a screening test for the purpose of increasing our sample size. This choice was made because of the considerably shorter time required for completing the blood alcohol analysis with a screening test. Luckey Drink-O-Meters were used to identify those people who had been drinking. Drivers who were identified as drinkers were then tested on the Stevenson Model 900 Breathalyzer in order to determine their exact blood alcohol content.

Although screening tests are notoriously inaccurate, it was decided that, if the analysis concentrated only on those individuals who were over the legal limit (.08%), this procedure would be reasonably efficient in detecting most, if not all, of these people.

Experimental Design

An engineering consulting firm was hired to conduct a "before and after" study in two cities, one of which was the experimental city (Edmonton), and the other of which was the control city (Calgary). The data were, (a) answers to attitude and knowledge testing questions, and (b) the blood alcohol levels of randomly selected drivers.

There were two research teams, one in Calgary, and one in Edmonton, each consisting of two Breathalyzer operators, four interviewers, one flagman, and two policemen. Each team operated between the hours of 7 p.m. and 2 a.m. on the nights shown in Table I.

TABLE I *Dates on which Interviews were Carried out*

Study		Thursday	Friday	Saturday
Before	November	25	26	27
	December	2	3	4
After	January	6	7	8
	January	13	14	15

A new site was visited each night by the research teams. Thus six sites were visited in each city during the "before" study. The same six sites were visited, and in the same order, during the "after" study.

Procedure

Whenever an interviewer was available, a police officer directed a car from the traffic stream into the survey site. The police officer did not speak with the driver: his job was merely to direct the driver from the traffic stream into the survey site. Once the vehicle was stopped, an interviewer approached the car and introduced the survey to the driver. The driver was informed that his participation was voluntary and that any information given to the survey crew would remain confidential and would not be used against him.

The driver was then asked to answer five questions (Figure 3), and to blow up a balloon which was part of an alcohol screening test.

QUESTIONNAIRE

City ____________ Time ____________

Site Number ____________ Date ____________

- -

Do you know what the legal limit of alcohol in your blood is?

Exact ________ Between .06-.10 ________ Don't know ________

How many drinks can a driver have in a three-hour period and still be below the legal limit?

1 ____ 2 ____ 3 ____ 4 ____ 5 ____ 6 ____ 6 plus ____ Don't know

Can you be charged with impaired driving even if your blood alcohol content is below the legal limit?

Yes ________ No ________ Don't know ________

Approximately what % of Canadian traffic fatalities involve the use of alcohol?

________ % Don't know ________

Do you think present drinking-driving laws are:

Adequate ______ Not tough enough ______ Too tough ______ Don't know ______

- -

Breath odour of alcohol Yes ________ No ________

Positive screening test Yes ________ No ________

Blood alcohol content ________

Figure 3 *Questionnaire used in the Edmonton Study.*

As a secondary task, the interviewers were asked to indicate whether or not they detected the odour of alcohol. If alcohol was detected by either the nose or the screening test, the person was asked to provide a breath sample for analysis on the Stevenson Model 900 Breathalyzer.

Screening tests and interviews were conducted at the car and only those drivers who were asked to take the Breathalyzer test had to leave their cars and enter the trailer.

Those drivers found to be over the legal limit had alternate transportation arranged for them. In some cases, these drivers were driven home by sober passengers. In other cases, taxis were provided free of charge by the research team.

RESULTS

The main results of this study are presented in Tables II to X. The Table of principal interest is Table X which presents a summary of the statistical significance of the differences which were obtained.

TABLE II *Pre-campaign Drinking Pattern in Calgary and Edmonton*

City	*Total No. of subjects*	*Number above .01%*	*Number above .08%*	*No. where BAC unav.*	*Percent with BAC above .01%*	*Percent with BAC above .08%*	*Percent Drinkers above .08%*	*Percent where BAC unav.*
Calgary	2,162	178	56	1,957	8.2	2.5	31.4	90.5
Edmonton	2,230	216	67	1,845	9.6	3.0	31.0	82.7
TOTAL	4,408	396	125	3,816	8.9	2.8	31.5	86.5

TABLE III *Post-campaign Drinking Pattern in Calgary and Edmonton*

City	*Total No. of subjects*	*Number above .01%*	*Number above .08%*	*No. where BAC unav.*	*Percent with BAC above .01%*	*Percent with BAC above .08%*	*Percent Drinkers above .08%*	*Percent BAC unav.*
Calgary	3,122	165	55	2,881	5.2	1.7	33.3	92.2
Edmonton	2,780	135	39	2,589	4.8	1.4	28.8	93.1
TOTAL	5,905	300	94	5,473	5.0	1.5	31.3	92.6

Number of People Over the .08% Level

As can be seen in Table IV, the percentage of drivers with blood alcohol concentrations (BAC's) above .08% was slightly higher in Edmonton than in Calgary before the campaign. This relationship was reversed after the campaign, with Calgary having a greater proportion of drivers above the legal limit. Neither the difference between the two cities before the campaign, nor the difference between them after the campaign, was statistically significant (Table X).

There is usually a drop in drinking activity following the Christmas/New Year season. Undoubtedly part of the observed drop was due to decreased drinking activity and this is one reason why a control city was used. Assuming the drop in the two cities would be about equal, the drop from 3.0% to 1.4% in the proportion of Edmonton drivers who were over the legal limit is significant.

Apparently, the Edmonton campaign was effective in reducing the number of impaired drivers (BAC greater than .08%) on the road. This is the most important finding of this study.

TABLE IV *Comparison of Drinking Patterns Before and After the Campaign*

City	*Time*	*No. of subjects*	*Number above .01%*	*Number above .08%*	*Percent with BAC above .01%*	*Percent with BAC above .08%*
Calgary	Pre-Campaign	2,162	178	56	8.2	2.5
	Post-Campaign	3,122	165	55	5.2	1.7
Edmonton	Pre-Campaign	2,230	216	67	9.6	3.0
	Post-Campaign	2,780	135	39	4.8	1.4

Knowledge of Legal Limit

Inspection of Tables V and X reveals that a significantly higher proportion of the population in Edmonton, both before and after the survey, knew the exact legal limit of alcohol in the blood. The number of people who knew the exact legal limit increased significantly in both cities following the campaign period, although this improvement was much greater in Edmonton.

Both the Edmonton and the Calgary campaigns succeeded in increasing the level of knowledge regarding the legal limit, although the Edmonton campaign was more effective (an improvement of 8.9% as compared with 3.0% in Calgary).

TABLE V *Comparison of "Knowledge of Legal Limit" Before and After the Campaign*

Accuracy	*% of Population*			
	Calgary		*Edmonton*	
	Pre	*Post*	*Pre*	*Post*
Exact	45.0	48.0	54.3	63.2
Between .06 and .10	1.9	5.4	2.0	2.7
Don't Know	52.8	46.3	43.3	33.3

Estimate of Safe Number of Drinks

Tables VI and X show that before the campaign period, drivers in Edmonton and Calgary were essentially the same in their estimates of how many drinks a driver could safely have within a three-hour period. After the campaign period, however, the patterns of estimates were significantly different for the two cities. The major differences are due to the decrease in the "don't know" category, and an increase in the "3" (correct category for Edmonton drivers.

Both cities evidenced significant changes from the before period to the after period. These changes consisted primarily in a decreased number of responses in categories above "3".

In conclusion, both campaigns were effective in decreasing drivers' estimates of the safe number of drinks, but the Edmonton campaign was more effective. In addition to becoming more cautious in their estimates, Edmonton drivers became more accurate (the number of people choosing category "3" increased from 33.7% to 50.1%).

TABLE VI *Comparison of Attitudes Regarding the Safe Number of Drinks*

	% of Population			
Safe No. of Drinks	*Calgary*		*Edmonton*	
	Pre	Post	Pre	Post
Don't Know	23.9	25.2	22.1	17.2
1	3.5	4.2	3.9	3.2
2	20.7	20.6	19.3	13.8
3	30.7	34.3	32.7	50.1
4	10.6	7.6	11.1	6.2
5	3.0	2.4	3.3	2.2
6	4.7	3.2	3.8	2.0
More Than 6	2.3	1.5	1.9	1.4

Knowledge of Culpability Even Below .08%

The fact that a person may be charged with impaired driving even though his BAC does not exceed .08% was known by a significantly greater number of Edmonton drivers than Calgary drivers, both before and after the campaigns (Table VII). Only the Calgary campaign was successful in producing a significant increase in the level of knowledge related to this point. This observation seems logical in view of the greater emphasis given to the enforcement function in the Calgary area.

Opinion Regarding Adequacy of Present Drinking-Driving Laws

This was the only question which attempted to measure attitude rather than knowledge. There was a significant difference between the two cities both before and after the campaign period. Before the campaigns, the main difference between the two cities was that more Edmonton drivers felt that the present laws were adequate, while a larger percentage of Calgary drivers felt that the present laws were too tough. (Table VIII).

TABLE VII *Comparison of Knowledge of Culpability below .08% BAC*

Accuracy of Knowledge	*% of Population*			
	Calgary		*Edmonton*	
	Pre	Post	Pre	Post
Don't Know	11.1	10.0	8.0	7.0
No	19.4	16.3	12.9	11.5
Yes	69.1	73.3	78.9	81.2

TABLE VIII *Comparison of Opinions Regarding the Adequacy of Current Laws*

Opinion	*% of Population*			
	Calgary		*Edmonton*	
	Pre	Post	Pre	Post
Don't Know	6.4	5.8	5.5	4.5
Too Tough	4.2	9.0	3.5	3.8
Adequate	35.8	36.2	33.1	41.3
Inadequate	53.1	48.5	57.6	50.0

Both campaigns appear to have been effective in producing significant changes in the attitude of drivers toward present laws. The Calgary campaign produced a decrease in the proportion of the population who felt that present laws are not tough enough, and an increase in the proportion of people who felt that present laws are too tough. The Edmonton campaign also resulted in a decreased proportion of the population who felt that the present laws are not tough enough. However, an increased number of Edmonton drivers felt that present laws are adequate.

In summary then, both campaigns increased the public's perception of drinking-driving laws as being tough. The emphasis on enforcement seems to have been overdone in the Calgary area, resulting in the feeling that present laws are too tough. This could be an important factor if, for example, the Alberta Government were to try to introduce tougher drinking-driving laws. People in the Calgary area would probably be more resistant to the introduction of new legislation than would people in the Edmonton area.

Knowledge of Alcohol Involvement in Traffic Fatalities

No significant differences in estimates of alcohol involvement in traffic fatalities were observed in either Calgary or Edmonton as a result of the campaigns (Table IX).

Significant differences were observed between the cities both before and after the campaigns. Both before and after the campaigns Calgary drivers had greater tendency to underestimate the involvement of alcohol, while a greater proportion of Edmonton drivers had accurate information (answers in the categories "41-50%" and "51-60%").

TABLE IX *Comparison of Estimates of Alcohol Involvement in Highway Fatalities*

Estimate of Involvement	*% of Population*			
	Calgary		*Edmonton*	
	Pre	Post	Pre	Post
Don't Know	23.9	21.9	22.1	21.0
Less Than 10%	1.4	1.3	0.9	0.8
11-20%	2.3	2.4	2.1	1.8
21-30%	5.6	5.9	4.9	4.3
31-40%	6.7	7.1	6.0	5.2
41-50%	19.2	21.5	24.7	24.4
51-60%	12.7	12.8	12.6	12.2
61-70%	9.6	8.4	8.8	9.6
71-80%	14.6	13.4	12.6	14.4
81-90%	2.6	3.2	3.7	3.0
91-99%	0.4	0.6	0.6	0.3

General

One factor which was not controlled or evaluated was the influence of the roadside surveys themselves.

One might speculate about a possible relationship between the observed changes in attitudes and their possible effect on the number of impaired drivers on the road. It is possible that if attitudes are changed in the direction of greater acceptance of present laws (present laws are seen as being neither too tough nor too soft), a greater proportion of the population will be more likely to comply with these laws. On the other hand, it is possible that if attitudes are changed in the direction of perceiving present laws as being too tough, a greater percentage of the population will reject the laws as being unjust, and will therefore ignore them.

Although this hypothesis is tenable, and would fit the framework of prior experience in other areas, there is no real evidence that this principle is operating in this particular instance.

CONCLUSIONS

Only the Edmonton campaign was successful in producing a significant decrease in the proportion of impaired drivers on the road. In interpreting the size of the drop (from 3.0% to 1.4%), it must be remembered that there is always a large drop in drinking

TABLE X *Results of Chi-Square Analysis of Differences*

Data	*Comparison*	*Chi-Squared Value*	*Probability that the Difference is a Real Difference*
No. of People over the .08% Level	Calgary before vs. Calgary after	2.1628	.8586
	Edmonton before vs. Edmonton after	15.3264	.9999
	Calgary before vs. Edmonton before	.6921	.5945
	Calgary after vs. Edmonton after	1.2079	.7282
Knowledge of legal limit of alcohol in the blood	Calgary before vs. Calgary after	51.8895	1.0000
	Edmonton before vs. Edmonton after	51.9832	1.0000
	Calgary before vs. Edmonton before	39.5467	.9999
	Calgary after vs. Edmonton after	149.6574	.9999
Estimate of safe number of drinks	Calgary before vs. Calgary after	34.4280	.9999
	Edmonton before vs. Edmonton after	182.8650	.9999
	Calgary before vs. Edmonton before	7.8386	.6529
	Calgary after vs. Edmonton after	185.1940	.9999
Safe No. of drinks (grouped analysis)	Calgary before vs. Calgary after	10.3639	.9987
	Edmonton before vs. Edmonton after	85.6321	.9999
	Calgary before vs. Edmonton before	1.2579	.7435
	Calgary after vs. Edmonton after	63.1660	1.0000
Knowledge of Culpability Even Below .08%	Calgary before vs. Calgary after	11.6798	.9970
	Edmonton before vs. Edmonton after	4.5100	.8954
	Calgary before vs. Edmonton before	53.6227	.9999
	Calgary after vs. Edmonton after	50.9854	.9999
Opinion regarding adequacy of present alcohol-driving laws	Calgary before vs. Calgary after	48.0002	.9999
	Edmonton before vs. Edmonton after	37.7860	.9999
	Calgary before vs. Edmonton before	8.9431	.9699
	Calgary after vs. Edmonton after	76.3876	.9999
Knowledge of alcohol involvement in traffic	Calgary before vs. Calgary after	11.7100	.6950
	Edmonton before vs. Edmonton after	11.3107	.6661
	Calgary before vs. Edmonton before	29.0806	.9987
	Calgary after vs. Edmonton after	33.4832	.9997

activity following the Christmas/New Year holiday season. Undoubtedly, part of this observed drop will be due to decreased drinking activity, and this is one reason why a control city was used. Since the decrease in drinking behaviour can be assumed to be equal in the two cities, a greater reduction in impaired drivers in Edmonton can logically be attributed to the effect of the campaign.

Both the Calgary and the Edmonton campaigns were successful in increasing the level of knowledge about particular points, and in changing the drivers' attitudes toward present drinking-driving laws.

Few adults or teenagers in the Edmonton area did not receive the message about drinking and driving. Most received it many times a different ways. The campaign was essentially low key in nature. Messages based on factual information and offering practical suggestions were well received by the mass media of communications and the public at large.

One word, "tremendous", was the way a safety official described the public reaction to the Edmonton Campaign. "We have never had so many people call with congratulations on the excellence of the campaign or with expressions of support for its objectives".

Many communications were received indicating that the topic of driving after drinking came up often in conversations during the holidays and that behaviour was changed for some people. The most frequent story was that people had taken the campaign advice and hired a driver, taken a cab or had ridden with a non-drinker. A few called off planned celebrations downtown in favour of organizing a house party with immediate neighbours. Cab companies reported that many people made reservations with them, which they said was uncommon.

The favourable public acceptance of the Edmonton Campaign may well be a key to the change in public acceptance of the law as being adequate. It also follows that acceptance of the law by the public may have been a factor in reducing the number of impaired drivers in Edmonton.

In addition to changing knowledge and attitude, the Edmonton Campaign was effective in producing the desired and all important behavioural change. It suggests that extra time and money spent on the Edmonton Campaign was worthwhile.

REFERENCES

1. Canada Safety Council. *Highway Accident Summary 1972.*
2. de Lint, J., Schmidt W. and Pernanen, K., *The Ontario Drinking Survey: A Preliminary Report;* Addiction Research Foundation, 1970.
3. Farmer, P. J., and Stroh, C. M., *The Edmonton Study, Catalogue T46-273,* Information Canada 1973.
4. Traffic Injury Research Foundation of Canada. *Survey of Alcohol Involvement in Fatal Motor Vehicle Accidents in Canada 1972.*

Seven Years Experience of Blood-Alcohol Limits in Britain

A. Bryan Saunders[1]

This paper reviews experience in Britain since the Road Safety Act 1967, and attempts, in the light of that experience, to propose criteria for the construction of laws against drinking and driving. To do this it is necessary to refer briefly to earlier history in Britain. Whatever lessons can be drawn from British experience, it would be rash to assume that they can be applied directly in other countries; social reasoning of this sort is notoriously non-exportable.

Such a review of British experience at the present moment is perhaps timely because the Minister for Transport has recently announced the setting up of a committee under the Chairmanship of Mr. F. A. Blennerhassett Q.C. to study the operation of the law on drinking and driving and to make recommendations. In setting up the committee the Minister noted that, although the 1967 Act had been highly successful, and although there was reason to believe it was still making a useful contribution to road safety, there had been some criticism of its operation, and there seemed litle doubt that further savings in road casualties could be achieved, particularly at certain times of day, if the number of people who drive after drinking could be substantially reduced. In short, the effect of the Act is wearing off. An analysis of the statistical information at present available and the conclusions to be drawn from it are contained in the paper by Sabey and Codling of the Transport and Road Research Laboratory (TRRL). The present paper attempts a more general approach to the legal and social questions now arising.

THE SOCIAL CONTEXT: ALCOHOL CONSUMPTION

Beer is the traditional alcoholic beverage in Britain, supplemented by spirits and (until recently, only in limited circles) by wine. There are restrictions on the number of retail outlets, on access to them, and on hours of business, and vigorous measures have been taken from time to time to restrict consumption, notably in the nineteenth century when cheap spirits became a severe problem. These restrictions, together with rapid social developments (better housing, the emergence of the salaried middle class, improvements in public education) combined with the economic depression of the inter-war years to cut the consumption of spirits per head in the 1930s and '40s to half the level of 1920. Only since 1970 has consumption per head returned to the 1920 level. Offences of drunkenness per 10,000 population show a parallel trend. Moderate increases in the rate of excise duty have (in a period of inflation) only briefly interrupted the trend. A marked feature of the 1960s and '70s is the rapid increase in consumption per head of wine. Consumption of alcohol with meals, both at home and when eating out, has become a more widely accepted part of life, and young people are drinking more. All in all, it has been the excise duties and changes in the size and distribution of national income which have had the greatest effect on patterns and quantity of consumption. Statistics of offences of drunkenness, hospital admissions for alcoholism, and deaths from cirrhosis and alcohol poisoning all show rising trends in relation to population.

---

[1] Assistant Secretary, Road Safety Directorate, Department of the Environment, London, England.

It would be idle to pretend that there is any undisputed measure of the extent of alcoholism in Britain, but equally idle to deny that all the evidence indicates an increasing problem, and one of great concern to public health authorities, (as in many other developed countries). This is not the place to discuss this problem, but it clearly has relevance to attempts to control drinking and driving. There is evidence, however, that 'problem drinkers' contribute less to the driving problem in Britain than 'social drinkers' (1).

THE COMMUNITY AND CONTROL OF MOTOR VEHICLES

The history of this fascinating subject has been thoroughly and entertainingly explored in the study by Plowden (6). It is here relevant only to note that until the 1930s motorists were generally a rich, and often unpopular, minority. In so far as they were themselves involved in the law-making process they well exemplified the principle that "criminals are other people". When charged with motoring offences they sought naturally enough to prove that, in their particular cases, no crime had been committed. There were three reasons why they were quite likely to succeed; they did not feel that they were criminals, they could afford the highest standard of legal advocacy, and the offences with which they were charged generally involved an element of judgment. It was notoriously difficult to prove that a driver had not exercised sufficient care, that he was driving too fast for the prevailing traffic conditions, that he had not made sufficient allowance for the possibility of unexpected behaviour by pedestrians, and so on. Convictions tended to be chancy and inconsistent. It was no less difficult to prove that the alcohol a driver had consumed had made him a less safe driver – especially in a society where the suspicion that one might not be able to hold one's drink could carry a stigma more severe than the suspicion of dangerous driving. Only a driver who was 'reeling drunk' might seem to a jury to be self-evidently a public danger behind the wheel of a car.

Since the Second World War car ownership has become widespread, but the tendency to regard motoring offences as in some sense less criminal than other offences which have comparable (or even less serious) effects on the safety or welfare of the community seems to have persisted. It is difficult to provide objective evidence of this, but there is a widespread belief that juries are more inclined to feel, in the case of motoring offenders, "there but for the Grace of God go I" than in the case of other offenders. Traffic offences are not all alike in this respect; breaking the speed limit, and driving with excess alcohol seem particularly liable to be regarded as "technical offences".

DRINKING AND DRIVING

The first law against drinking and driving was that in the Licensing Act 1872 which made it an offence to be "drunk while in charge on any highway or other public place of any carriage, horse, cattle or steam engine". How was it, one may reasonably ask, that if Parliament recognised the problem 100 years ago we had to wait until 1967 before passing a law which dealt with the matter relatively effectively? The difficulty lay in the absence of evidence which could go to the root of the social mischief. The mischief was the danger caused by driving a motor vehicle while affected by alcohol. The difficulty was to prove danger when moderate amounts of alcohol had been consumed. The trouble with the drunken driver was that if he was so drunk as to be obviously dangerous he was very likely too drunk to drive. If he had consumed a more moderate amount of alcohol the manner and the extent of the danger he embodied was much less obvious. As a result, court decisions were uncertain and inconsistent. It was fifty years ago that this point was recognised, and the British Medical Association published a report on tests for drunkenness in 1927 (2). But it was not until the 1950s and early '60s when research, in Britain and other countries (4), proved the statistical connection between blood alcohol levels and liability to involvement in an accident, that the necessary firm evidence was available. It was Borkenstein's Grand Rapids study in particular which provided the experimental warrant for the British Act of 1967, though evidence from other sources also strengthened the case.

THE DIFFICULTIES IN THE WAY OF THE 1967 ACT

The circumstances which cause a particular driver to be involved in an accident at a particular time and place are notoriously complex and difficult to determine and evaluate. Apart from external factors such as weather and road geometry; skills, attitudes, and other personality factors in the driver may play a large or decisive part. Even now, despite the amount of research that has been devoted to the problem, the detailed mechanism by which alcohol impairs driving cannot be precisely and quantitatively described. One driver may be a greater danger sober than another with a Blood Alcohol Concentration (BAC) of 100 mg/100 ml. Nearly a century of experience in the courts showed that it was generally impossible to prove that a particular driver was culpably dangerous by reason of the alcohol he had consumed. A law was necessary that would make it unnecessary to prove the social mischief in each particular case. Such a law is patently rough justice – it had to apply to everyone alike, despite the fact that alcohol does not affect everyone alike. It had to be a legislative "blunt instrument", justified by broad statistical evidence, and making no fine allowances for individual differences of personality or physiology. This was not in itself a very great obstacle – many laws are of this sort, court decisions under the earlier laws had not been very just or consistent, and speed limits offered an obvious analogy in the traffic field. However, there was an important difference; speed seemed self-evidently dangerous; it felt and looked dangerous. Speed limits were applied long before the statistical evidence for the effect of speed on accident rates and severity had been established. But many drivers sincerely believed that small amounts of alcohol actually improved their driving. To justify a general prohibition on driving after drinking it was necessary to convince them that this sincere belief was an illusion. It was necessary to show that the illusion was one of the effects of the alcohol itself, and perhaps its most sinister effect. This effect of alcohol had of course been noted in antiquity, and references to it can be found in ancient literature[2]. There was also experimental evidence of it in the case of drivers.

Once a "blunt instrument" or "general limitation" approach was seen to be justified, it still remained possible, in theory, to proceed in a number of ways. For example, licensees of drinking establishments might have been made responsible for confiscating the ignition keys of any client who arrived by car and consumed more than a specified "Driver's tot". This would have laid an impracticable and intolerable responsibility on licensees; and what about the driver who drank at home – or kept a bottle in the car? The only workable law would be one that made the driver himself responsible; but responsible for what? Purists would say "responsible for refraining from driving for at least 12 hours after drinking any alcohol at all." But the prescriptions of purists are rarely acceptable as social legislation and therefore a limit has to be set. This imposed the problem of finding a legal definition for the limit to be imposed. There was really no alternative to a limit defined in terms of BAC. The correlation of BAC with accident risk had been proved; it was known that BACs, for a given amount of alcohol consumed, varied widely, not only from person to person, but also in relation to the nature of the drink consumed and many of the surrounding circumstances; and BACs could be measured with reasonable economy and accuracy. So a limit defined in terms of the type and quantity of drink consumed would not be practicable, but it would be practicable to make the driver responsible for keeping below a specified BAC.

However, if the crime is to be to drive with a BAC above a specified level, how far is the driver's responsibility to go? Is conviction to depend on proof that he drove knowingly and wilfully with excess blood alcohol? Few people thought that this would work. Every defendant would plead that his intentions were pure, and that the BAC shown by analysis was an insoluble mystery in view of the negligible quantity of drink actually taken. Therefore, the offence had to be "absolute" – the offender's state of mind must be irrelevant. He might be a callow novice in the world of alcohol, a hardened business drinker taking a calculated risk, or an alcoholic unable to control his drinking. All this would be irrelevant to the proof of guilt, and, with the sole exception of a person genuinely deceived as to the nature of what he was drinking, it was to be no protection against the automatic penalty of disqualification for at least a year (but not necessarily irrelevant to the consideration of other penalties the court might impose – nor to disqualification for *more* than a year if the court decided it was justified).

How was the evidence of BAC to be obtained? A driver could be required to give a specimen of breath at the roadside, but breath analysis was not politically acceptable as sufficiently accurate and reliable for conviction in court, so a specimen of blood or urine would be required. This meant that the police must be given power to require the suspect to provide the evidence against himself.

The public debate of these questions did not, of course, take the form set out in the preceding paragraphs. The argument set out here is a condensation of a diffuse public discussion stretching over a decade and more. The debate had been both expert and general, and the British Medical Association had played no small part in bringing out the facts and dispelling misconceptions. By 1966 legislation was judged to be politically possible.

The Bill laid before Parliament in 1966 provided for breath analysis to be used as a screening test that is, no one should be required to provide a specimen of blood or urine unless a breath test had first proved positive. Nevertheless, it gave to the police a formidable power and the thoughts of the legislature turned to safeguards. The relations of the police with the public in Britain were (and are) generally good, and there is no evidence that any specific abuses were widely feared, but the random breath-testing power proposed in the first Bill caused considerable controversy. It was argued that law-abiding drivers, who might well be teetotallers, could be stopped by the police and submitted to the indignity of being required to blow into a bag. This first Bill was lost by the Dissolution of Parliament, and the second draft of the Bill introduced after the election, no longer provided for random testing. In introducing the new Bill the Minister (Mrs. Barbara Castle) said "I myself do not accept that there is anything unfair about an entirely random test . . . . .", but she added that evidence had come to her from Members of Parliament and through her department that there was widespread public feeling that an issue of individual liberty was involved. She made clear that although she had never shared that view, she was anxious to make an important start in changing public attitudes and recognised that this could not be done by means of legal procedures which were widely regarded as unfair to those affected by them. She recognised the need for a measure ". . . . . which will command widespread public cooperation. This is essential if we are to change public attitudes. . . . we have attempted to retain some element of the random test system while concentrating the effectiveness of the deterrent." The new Bill provided power to test drivers after an accident, after they had committed a moving traffic offence, or when the police had reason to believe that they had alcohol in their bodies. The Minister made clear that what she meant by her reference to retaining some element of the random system, was that accidents themselves are to some extent random, although drivers involved in them are more likely to have been drinking than other drivers. She pointed out that the powers in the new Bill made a more efficient use of police resources by concentrating on drivers who were more likely to have been drinking than would those in a completely random sample. Finally, she said that there was no intention that the police would "lie in wait" for motorists near drinking establishments.

---

[2] See for example, Proverbs 20:1

It is difficult to disentangle all the threads in the argument about random testing. On the one hand, it may be argued that completely random testing is the fairest method of all. If the police pick vehicles from the traffic stream by some random method, they have no way of knowing which drivers the net will catch and the assurance of randomness eliminates the possibility of malice, the victimisation of social groups, or the showing of favour. On the other hand, the very fact that the random system means that *anybody* who drives is liable to be tested appears to have constituted the mainspring of political objection. As things have worked out, it is arguable that the absence of a power of random testing has not weakened enforcement of the law. The fact that 60 per cent of the breath tests administered by the police in Britain are positive and the fact that 30 per cent of breath tests are administered after accidents, suggests that that law has "concentrated the effectiveness of the deterrent". The question of "lying in wait" may come nearer to the true problem of enforcement than the question of random testing. It has been argued that the Act does, in fact, give the police power to "lie in wait". It has been pointed out that a policeman who sees a person leave a bar and drive away in his car has "reasonable cause to suspect him of having alcohol in his body". In practice, however, the police do not do this and the question has not been tested directly in the courts. In any case, whatever the correct interpretation of the present law, "lying in wait" would probably be regarded as politically indistinguishable from random testing, and therefore politically unacceptable, unless Parliament had first reconsidered the matter.

There is no doubt that the 1967 law was highly deterrent in the initial stage. Because the courts were required to disqualify offenders for a year at least meant that the penalty was certain and unpleasant. The main provisions of the Act and its initial effect on accidents have been thoroughly reported elsewhere (1). What remains obscure is the mechanism by which the accident savings were achieved. The new law had been supported by heavy publicity and the severity and certainty of the penalty were widely known. What the individual driver did not know, however, was the chance that he would be required by the police to submit to a breath test or the likelihood that his drinking pattern would place him over the BAC limit. The wide variations of blood alcohol level induced in different individuals by similar quantities of drink, or in the same individual according to the attendant circumstances were well known to the government, who consequently declined to give any guidance, except that those who intended to drive should not drink at all. Coroner's statistics of the BACs of drivers killed in accidents in the year following the legislation show that there was a dramatic fall in the proportion over the limit in all age groups. The effect has since largely worn off, especially among the younger age groups (3), but it is not possible to infer the reasons with any precision. Have drivers discovered that the chance of being required to take a breath test is less than they feared? Have they revised their estimates of the amount they can drink without exceeding the limit – possibly to an unrealistic degree? Have they just forgotten about the law? It is interesting that the apparent decline in the deterrent effect of the legislation has accompanied a continual increase in the number of breath tests administered. Very little government publicity against drinking and driving has been promoted during the last five years, and it is possible to speculate that the perception of drivers of the risk of being breathtested has been falling at the same time that the actual risk of being tested has been rising. In the absence of a roadside screening programme (which poses certain administrative difficulties) there is no reliable means of estimating what proportion of the drivers on Britain's roads at any time are over the limit, and it is therefore not possible to estimate the proportion of offenders actually detected. It may be that this is sufficiently low for an increasing numbers of drivers to find the risk acceptable, despite the fact that the number of tests is rising.

The high initial impact of the 1967 Act did not prevent those who were charged under it from exploring every legal technicality in the hope of avoiding disqualification. The main weight of the attack focussed on the question of whether the accused was "driving or attempting to drive", when the police asked him to take a breath test, and whether the BAC established by analysis, corresponded to the actual BAC at time of driving.

Because it is not possible for a blood or urine sample, or indeed a breath sample, to be taken from a driver while he is actually driving, the law must provide a procedure, starting from the point at which he is driving and the police first have reason to form a suspicion, and leading by a connected chain to the point at which a sample is taken. The law protects motorists from the oppressive use of breath testing by the police by requiring that it may only be applied to somebody who is "driving or attempting to drive", or is the driver of a vehicle involved in an accident. It is at this point that it has been possible for ingenious defence advocates to prise open a gap. A driver who had been involved in an accident was badly shaken and had been give one or two drinks by a kindly bystander. The BAC revealed by a subsequent analysis was such that the prosecution were able to show that it must have been over the limit even before the further alcohol was taken. Nevertheless the driver was acquitted on the ground that the BAC revealed by analysis was not the BAC while driving. A driver followed by two plain clothes officers, because of his wild and erratic driving, was eventually stopped and held pending the arrival of a uniformed officer with breath testing equipment. He was held not to be still driving at the time when he was breath tested and therefore acquitted. In the early years of the Act some drivers escaped by managing to get home and park their cars before being caught by the police, and subsequently convincing the court that they were no longer "driving" when the breath test was administered. The most recent appeal decisions have largely stopped up these gaps by holding that, provided there is a continuous process from the time when the accused was driving and the police formed a reasonable suspicion, to the time when the breath test was administered, then the accused is still "driving" at the relevant time. Lord Hacking proposed amendments in the House of Lords in a debate on the Road Traffic Bill on the 17th December 1973 (5) which he said were intended to set out separately the offence itself and the proof of the offence. His amendments would have provided that the BAC found on analysis would be deemed to be the level when the accused was last driving, unless he could prove otherwise. The Government felt that such an amendment would go too far, and the questions will now fall to be considered by the Blennherhassett Committee.

In terms of the number of guilty motorists who escape conviction by means of them, the technical loopholes are certainly not important. The numbers of breath tests, of positive breath tests, of prosecutions, and of convictions in recent years are shown in Table I.

TABLE 1 *Number of Breath Tests and Prosecutions in England*[a] *(1968-1972)*

	No. of breath tests administered	No. of breath tests positive	Positive %	No. of "false positives" (not confirmed by analysis)	No. remaining.	No. of prosecutions	No. of convictions.	Prosecutions successful. %
1968	48,100	26,400	55	3,800	22,600	18,900	17,400	92
1969	55,100	31,800	58	5,500	26,300	25,500	22,800	89
1970	69,500	39,400	56	7,400	32,000	28,000	25,200	90
1971	91,200	56,300	60	11,800	44,500	41,400	37,600	90
1972	112,700	69,700	62	15,200	52,500	50,300	46,000	92
Allow for about 3 months' cases carried into '73, less 3 months' cases carried in 1968	−17,000	−10,800		−2,900	−7,900			
TOTAL FOR 5 years	359,500	212,800		40,800	170,000	164,100	149,000	91

[a] Source: Home Office: Return of Offences Relating to Motor Vehicles, HMSO (ISBN 010 243273 2)

It will be noted that the totals for the five-year period of 1968-72 (allowing for the fact that the courts carry forward a few months' business each year) show that about 96 per cent of the positive breath tests confirmed by analysis lead to prosecutions, over 90 per cent of which lead to conviction. Also that the number of breath tests is rising steeply and continuously. Nevertheless, there is another argument for looking carefully at possible loopholes in the law. It is not just, nor is it politically acceptable, that those who can afford the services of adroit advocates should be able to escape the consequences of their offences by the exploitation of technical loopholes. It may well be for this reason, rather than the numbers involved, that loophole cases attract a great deal of public attention.

The 1967 Act gave very little power to Ministers to alter the details of the measure by regulation. They could alter the BAC limit, specify a different breath testing device for use by the police and authorise the analyists who carry out analysis. Beyond this, changes could only be made by returning to Parliament for a new Act. There were no doubt good reasons for proceeding in this way at the time; the Act was very controversial and imparted a new principle into the law. Parliament would not readily have given the Government power to alter the detail of the law without returning for re-enactment. It is possible that some of the loopholes opened up in the courts (and most of them eventually closed again by the Higher Courts) might have been closed more quickly and with less effort if there had been wider regulation – making powers. This is by no means certain, however, since governments are naturally reluctant to use a power to make regulations for the purpose of amending case law where it seems likely that the courts themselves may put the matter right eventually.

It is a feature of the procedure specified in the 1967 Act that it places a considerable burden of work on the police at the time the offence is discovered. A policeman who administers a breath test which proves positive must go through a procedure which may well take more than two hours. The removal of a patrol car from the road for so long a period is a considerable drain on resources. The evidence afforded by the "Alcotest" would certainly not be sufficiently accurate or reliable to be used for purposes of prosecution, but the search for a means of simplifying and, if possible shortening, the procedure the police have to follow is of some urgency. Whether a two-stage procedure can be avoided seems questionable. In any case, further police time must be taken up in court proceedings.

Is it possible to draw from British experience with the 1967 Act a set of principles which should inform the drafting of a law against drinking and driving, so as to increase the likelihood that it will be effective? The following criteria are proposed for consideration:

1. The law should define an offence or offences which are clearly accepted in the public mind as representing substantial danger to road users.

2. The offence or offences which the law defines must be capable of proof by specific objective information. Proof must not depend crucially on the opinion of witnesses, police officers or experts.

3. The law must be enforceable, at a sufficiently high rate of detection to be respected, without undue demands on police resources and technical means.

4. The law must provide penalties which are effective to deter offenders, and to protect other road users.

5. The law must be fair and reasonable and it must be socially undiscriminating: it must bear, and be seen to bear, equally on rich and poor, and on all groups within the community.

6. The law should, so far as possible, be adaptable, that is to say, it should be capable of small modifications (to deal with defects which emerge in practice) without the necessity for re-enactment.

These principles are not independent of one another, nor are they independent of time. The enforceability of a law will be strongly dependent on its acceptance by the motoring public as being necessary to deal with a social mischief, and appropriate for that purpose. Enforceability also depends on the law being seen to be administered in an effective and even-handed way. Resentment and disrespect for the law is liable to follow if a high proportion of offenders escape by luck – and *a fortiori* if by wealth or influence people are seen to escape. It is worth noting here that, although there has been some exploitation of legal technicalities, the law in Britain has generally operated in an even-handed manner and influential members of all professions have not escaped conviction. Disqualification from driving has proved a most effective penalty. Mandatory minimum penalties are not popular with the courts, but it seems unlikely that this law would have had so great an effect if mandatory disqualification had not been provided. This provision makes it the more important, however, that the law continues to command general public respect. This inevitably raises the question whether the heavy publicity promoted seven years ago when the law was introduced can still be regarded as having discharged the government's duty of public information. It should not be forgotten that convictions provide a continual stream of publicity for the law, and continuing controversy about it ensures that it gets considerable coverage by the media. Whether this is an adequate substitute for official information, renewing awareness of the social evils that flow from drinking and driving, is a question for consideration.

These and other questions will be considered by Mr. Blennerhassett's committee. There is little room for doubt that their work is now urgently needed.

REFERENCES

1. Beaumont, K., and Newby, R. F., *British Countermeasures to the Problem of Alcohol and Drugs in Road Safety*. Department of the Environment, London, 1971.
2. *British Medical Association, Report of Committee on Tests for Drunkenness.* London, 1927.
3. Codling, P. J., and Samson, P., *Blood-alcohol in Road Fatalities before and after the Road Safety Act 1967*, TRRL, Crowthorne, Berkshire, 1974.
4. Garwood, S., and Johnson, H. D., *Statistical Studies Leading to the Breath Tests.* Manchester Statistical Society, Manchester, 1969.
5. House of Lords: Official Report, Vol. 348. No. 24, 17 December 1973, Col. 126.
6. Plowden, J., *The Motor Car and Politics 1896-1970*, The Bodley Head, London, 1971.
7. Sabey, B. E., and Codling, P. J., Alcohol and Road Accidents in Great Britain, In *Proceedings of the 6th International Conference on Alcohol, Drugs and Traffic Safety, Addiction Research Foundation*, Toronto, 1975, Section 1.

Socio-Medico-Legal Aspects of Alcohol and Alcoholism

Robert J. Joling[1]

Amendment XXI, adopted in 1933, repealed the Eighteenth Article of Amendment to the Constitution of the United States, which had prohibited the transportation, importation, possession or use of intoxicating liquors within and between the several states. Within ten months of its proposal, three-quarters of the states had ratified this Amendment. Now, as a result, our country can reflect upon a history of 41 years of alcohol consumption with its attendant influences for good or evil.

If we consider law in the "statutory" or in the "common law" (decision) areas as being the express will of the people through either elected representatives or a responsive judiciary, it would seem that the general population has little concern for serious health problems. At a time when the average American citizen expects the best medical care as a matter of inherent right (and at the lowest possible cost), little heed is given to the horrendous proportions of our fourth leading national health problem, alcoholism (1). Only three other health problems (mental illness, heart diseases, and cancer) surpass that of alcoholism.

The World Health Organization Committee of Experts defines alcoholics as:

> *. . .those excessive drinkers whose dependence upon alcohol has attained such a degree that it shows a noticeable mental disturbance or an interference with their bodily and mental health, their inter-personal relations, and their smooth social and economic functioning; or who show the prodromal signs of such developments.* (1, p.16)

It has been estimated that more than 80,000,000 persons in the United States use alcoholic beverages. Six per cent are considered excessive users and possibly problem drinkers. One to one-and-one-half million persons are probably classifiable as chronic alcoholics (6). Considering these statistics, it is not surprising that the United States counted 54,521 traffic deaths in 1969 and more than 50,000 each year thereafter in which an estimated 50 to 60 per cent involved the use of alcohol (11).

SOME EFFECTS OF CULTURAL ATTITUDES IN AMERICA

Social Ambivalence

Myerson refers to American cultural attitudes toward alcohol drinking as "social

---

[1] President Elect and Fellow of the American Academy of Forensic Sciences. University of Arizona, College of Medicine, Tucson, Arizona, 85724, U.S.A.

ambivalence" (5). He asserts that this ambivalence limits the development of the stable attitudes toward drinking that is found in some other cultures. This leads to the conclusion that because social controls are limited, drinking becomes a bizarre and uncontrolled form of behavior.

Skolnick states:

> *Total abstinence teaching seems to be a double-edged weapon. On one side, it expounds and implants a repugnance to drinking as well as to intemperance; on the other, by identifying the act of drinking with intemperance, it suggest (sic) that the way to drink is, likewise, intemperately. It thus, in some people, inadvertently encourages the behavior it most deplores.* (8, p.468)

He further argues that persons who become alienated from their abstinence backgrounds may use excessive drinking as a reactive means of fleeing from or acting out their frustrations resulting from early social teachings concerning alcohol drinking learned in the home, the church, and their community. In other words, problem drinking becomes a symbol of revolt and an escape from inculcated values. Given this theory, it was argued that if alcohol drinking were a more thoroughly interdigitated social custom within the United States, competing opposites, abstinence and uncontrolled drinking, would be neutralized and the pathology of alcoholism eliminated. As substantiation of this claim we might cite the low alcoholism rates of the Jewish and Italian subcultures, and the conversely high rates among Irish and Scandinavians and Papago Indians. For the Jews, the drinking of alcohol is traditionally an integral part of religious ideology and the consumption of alcoholic beverages is learned and practised within a controlled family setting. (Drunkenness, as related in the Biblical account of Noah and his sons or Lot and his daughters, is a social negative; sobriety is a virtue of the Jewish culture.) For the Irish, however, the drinking of alcohol in the context of religious ideology is not a factor and therefore does not offer a specific controlling influence within the family setting. To the Irish, drinking may be hedonistic or even utilitarian: its anesthetic effect may be regarded as a useful means of handling psychic tensions. So, to the Jew the consumption of alcohol is part of his culture; but to the Irishman it is part of cultural ambivalence.

If the foregoing cultural attitudes toward drinking exist in America, it is apparent that they are far from uniform. American culture recognizes religious approval and disapproval and the aspects that promote utilitarian acceptance, in determining attitudes toward the consumption of alcohol.

The Temperance Movement

Active during the early part of the twentieth century, this Movement was largely responsible for the adoption of the 18th Amendment to the Constitution of the United States. In America, belonging to the Women's Christian Temperance Union was often a middle-class, small-town, status symbol. Today, on the other hand, total abstinence is often interpreted as a negative status symbol, apparently resulting from the cosmopolitan attitude of the socio-economic middle-class group, which tends to support the norm of responsible drinking.

Mulford and Miller, in their Iowa survey (1960), found that 40 per cent of the adult population were abstainers, while 60 per cent were users of alcohol (4). In 1961, Knupfer's study indicated that in California 13 per cent of the population were abstainers, while 87 per cent were users of alcohol (2). Both studies indicated that the amount and frequency of alcohol consumption vary with the socio-economic-cultural attributes of age, sex, education, residence, and religion (7).

Training of Professionals and Governmental Workers

As a result of past paternalistic attitudes of governmental agencies, together with attitudes of professional workers such as psychiatrists, physicians, social workers, and nurses, who were primarily responsible for the treatment of the alcoholic, punitive and moralistic approaches to treatment prevailed. Effective therapy can not be based on such individualistic attitudes, which among other things undermine the necessary relationships between therapist and effective therapeutic treatment. Individualistic attitudes and ineffective treatment arise when the traditional training of professionals in medicine, nursing, social work, law and law enforcement provides them with very little study in the field of alcoholism, and when their contact with the problem is minimal.

Treatment

In America, the attitudes toward alcoholics and alcoholism began to change from the conceptualism of immorality and the punitive viewpoint to that of disease orientation. It now devolves on the professionals, including law enforcement officials, to disenfranchise their professional conduct and attitudes from the acceptance of ambivalence, moralism, and pessimism regarding treatment outcomes. It would appear that such attitudes, when they still exist, stem from the therapists' refusal or inability to understand or accept the chronic nature of the disease, with the attendant complex needs and methods of treatment. In reviewing the earlier attitudes, it is not difficult to understand the climate of treatment that would develop where the frame of reference for law enforcement agencies, whether police-oriented or court-oriented, was deterrence, punishment, avenging a wrong, and rehabilitating a "wrongdoer."

The ambivalent social sttitudes of the American culture, together with the lack of experience in the professions in this neglected area of social problems, tended to create negativistic attitudes and skepticism relative to the role of the judiciary and quasi-judicial functions of the various levels of law enforcement and helped to produce an attitude of rejection of the alcoholic, either as an inmate, a patient or a client. Thus the problems of "treatment" became, in some instances, an effort of "detoxification" in the "drunk tank" of the jails, limited to the immediate physical needs of the recipient, with minimal attendant care.

Another factor that is sometimes overlooked in considering treatment for the alcoholic is that he usually resents and rejects treatment as a "psychiatric patient" which he interprets as being placed in the same category as the mentally ill.

The approach of Alcoholics Anonymous (AA) is psychotherapeutic. Although it has not provided an answer to the over-all problem, it cannot be denied or overlooked that it has provided assistance in coping with the problem for many. Strong support by other members, group therapy, and the quasi-psychophilosophic approach have achieved a remarkable success.

IMPORTANCE OF A MULTI-DISCIPLINARY APPROACH

It must be recognized that the problem of each alcoholic has to be dealt with on an individual basis, taking into account his socio-economic background, cultural heritage, ecological nutritional-disease inventory, and psychologically evaluated personality traits. Unless this is accepted, there can be no successful treatment. A program that disregards the client's socio-economic, ethnic and cultural background is doomed to failure. For example, ascetic Protestantism automatically negates the North American Indian's traditional value of manhood. There must be integration of values and rational orientation to social reality. The value conflicts involved in the cross-cultural variables must be recognized; and cross-cultural exchanges of information and resources must be investigated for a treatment program to have the potential of success.

Some of the old clichès must be abandoned: the most costly health problem facing America cannot be defined as simply the result of psychiatric conflicts within the individual, nor can we view alcoholism as a psychological problem based on the immaturity of the patient. It is not enough to try to explain the problem of alcoholism by saying that the individual has failed to develop a capacity to cope successfully with his daily confrontations, or that he uses alcohol to escape the reality of an uncomfortable situation. The lack of an acceptable definition or diagnosis of a "typical" alcoholic points up a significant medical-legal-social problem far more complicated than such over-simplified statements allow. It must be kept in mind that no accurate, scientific description of a "typical" alcoholic has found acceptance in any of these disciplines.

The problem, of course, is not new. Studies have been made concerning the physiological effects of alcohol, the symptoms of alcoholism, treatment, both medical and psychotherapeutic, and rehabilitation, to name some of them. There have been many alcohol programs of one kind or another, including in-patient hospital programs, private clinical sanitariums, out-patient and consultation services. Emphasis was, and still is, greatly drawn toward the psychiatric approach – psychotherapy and psychological counselling, following the initial treatment of physical symptoms, in spite of the fact that the American Medical Association classified alcoholism as a medical problem in 1956. They urged the general hospitals to admit alcoholics for treatment.

Today there is general agreement that alcoholism is a community and national health problem. The federal government of the United States has become increasingly concerned and today seven agencies of the Department of Health, Education and Welfare are involved in the study and research of areas of the alcohol problem. The major effort of government research is centered at the National Institute of Mental Health of the Public Health Service (10).

Research indicates the need for:

New techniques in the rehabilitation of alcoholics.

Methods to prevent or minimize the damaging effects of alcoholism on family and other social relationships.

Methods to prevent fraudulent advertising relative to "cures."

Determining the environmental and ecological factors which play a role in susceptibility to alcoholism.

Studies relating to metabolism and effects of alcohol on the central nervous system.

Socio-cultural characteristics of alcoholics (including the need for education, acculturation, and social use standards).

Standards which would be indicative of variables supporting consumption patterns and tendencies toward alcoholism (with suggested corrective processes).

Uniform reporting of interrelated information at all levels of governmental and non-governmental institutions.

Liaison between agencies researching or treating alcohol problems.

A co-ordinating agency for all alcoholism programs.

A readily available data bank source of technical, professional, and lay information relating to alcoholism.

Training programs for medical and legal professions, the judiciary, law enforcement officials, psychologists, psychiatrists, social workers, nurses and any other personnel engaged in the treatment and rehabilitation efforts.

One final quotation exemplifies the problematic relationship between social and physical factors. Dr. Melvin H. Knisely, head of the Department of Anatomy at the Medical College of South Carolina, speaking at the 28th International Congress of Alcohol and Alcoholism, held in Washington, D.C. in 1968, (9) stated:

> *When his level of social drinking is such that he feels very happy, a man is beginning to kill a few brain cells. The damage is permanent.*

A heavy intake of alcohol can cause changes in the blood and blood vessels, and brain cells can be destroyed as a result of oxygen stagnation (loss of normal oxygen supply). Thus, it is not surprising that in heavy users of alcohol outward manifestations of brain damage are noticeable by increased forgetfulness and loss of efficient work capabilities.

CONCLUSION

The totality of the complex alcohol problem as it relates specifically to the individual should now be recognized. There is no singular panacea for the treatment of the alcoholic. Each must be regarded as a unit within the total problem and conversely each problem must be viewed in the light of the total individual. Recognizing the component factors of cultural heritage, socio-economic environment, ecological and biological factors, psychiatric and psychological stresses in light of the disease concept may give the key which will open the door to successful understanding, treatment and rehabilitation of the alcoholic.

REFERENCES

1. Expert Committee on Mental Health, Alcoholism Subcommittee, Second Report, *WHO Techn. Rep. Series* (Sec. No. 48), August 1952.
2. Knupfer, G., Characteristics of Abstainers. A Comparison of Drinkers and Non-drinkers in a large California City, *Report No. 3, California Drinking Practice Study,* Berkely, Calif., Division of Alcoholic Rehabilitation, Dept. of Public Health, November 1961.
3. Lewis, J. R., and Jumping Eagle, *A Proposal for a Study of Arizona Indians: Perspective on Alcohol,* Center for Community Dynamics, Tempe, Arizona, 1971.
4. Mulford, H. A. and Miller, D., Drinking in Iowa, II. The Extent of Drinking and Selected Sociocultural Categories. *Quart. J. Stud. Alcohol* 21: 26 (1960).
5. Myerson, A., Alcohol: A Study of Social Ambivalence, *Quart.J.Stud.Alcohol* 1:13, (1940).
6. Pittman, D. J., *Alcoholism*: *A Sociological Point of View*, A Paper presented at the Conference on "The Role of the Clergy in Understanding and Counselling the Alcoholic and Family," Fargo, North Dakota, April 1960.
7. Pittman, D. J., Drinking and Alcoholism in American Society. In: *Alcoholism, the Total Treatment Approach*, Cartanzaro, R. J., (ed.), C. Thomas, Springfield, Illinois, 1968. Chapter 5, p.71.
8. Skolnick, J. H. Religious Affiliation and Drinking Behaviour, *Quart. J. Stud. Alcohol,* 19: 452 (1958).
9. *Tucson Daily Citizen,* September 20, 1968, p.15.
10. U.S. Department of Health, Education and Welfare, Public Health Service, Alcoholism, *Public Health Service Publication No. 730,* 1969.
11. U.S. News and World Report, *Model Program? How California Cut Road Deaths,* May 8, 1972, p.102.

Can Alcohol Education Change the Role of Youth on Our Highways?

Lee N. Hames[1]

Can alcohol education change the role of youth on our highways? Surprisingly, perhaps, a definite answer can be given. It is an unequivocal "no."

Without a briefcase full of scientific research as validation, one probably should not be that positive about anything, but in this case it is not much of a risk since what is to be changed is not basically an alcohol-related problem. Certainly some of the high mortality and morbidity rates amassed by young people on our streets and highways are alcohol-related, and also, some questions have arisen recently as to whether the lowering of the legal drinking age in some jurisdictions may increase that toll; but it seems obvious that what happens to young people behind the wheel is related more to 'growing-up' than it is to excessive drinking. Why, then, should we spend time here discussing something we have already claimed cannot greatly change the picture?

First of all, while drinking is not the primary reason that young people have traffic safety problems, it definitely is *a* cause; and whether or not it becomes a more serious cause because of the lower legal drinking age, it justifies further interest and study.

Secondly, if we can teach young people how to drink sensibly, chances are that many of them will continue to do this as adults.

Thirdly, and most importantly, alcohol education is a part of a larger picture in which the school, home and community all contribute in providing students with a maximal opportunity to select a well-balanced, sensible and responsible way of life.

Of course, alcohol education in itself covers a vast expanse in the field of education. Even after severely limiting the scope of our information gathering, we still had a desk piled high with references. Title after title implied information about results, but the copy primarily covered teaching methods. Hard, definitive research results concerning the effectiveness of the teaching are scarce – a Phoenix survey, for example, surveyed attitudes and opinions, but did not relate to the quality of the education (23).

Before discussing anything about quality, however, let's first look into how much alcohol education is legally required. A 1970 National Safety Council study of the alcohol education statutes in the United States determined which states required alcohol education, at what class level the teaching was being done, and whether or not alcohol information was included in the driver education curriculum (12). The results were quite impressive, but as they say in some rather poor jokes which were plaguing us a year or so ago, "Now for the bad news."

---

[1] American Medical Association, Chicago, Illinois, 60610, U.S.A.

There is a world of difference between the letter of the law and what is actually taught, and in the case of some of the statutes, that may be just as well. The study found, for example, that one state required the teaching of "the effects of alcohol on health and character. . ."; another state required "a course of study on the *evil* and injurious effects. . ."; another required that "not less than one hour of the school day shall be set apart for instruction and appropriate exercises," the day designated being the third Friday in January of every year, which shall be designated as Temperance Day; still another legislated that "scientific temperance" shall be taught; and finally, one state required that "moral instruction" should be given, "intended to impress upon the minds of students the importance of truthfulness, temperance, purity, public spirit, patriotism, respect for honest labor, obedience to parents and due deference to old age." In fairness it should be pointed out that both of those last states required in addition that special instruction be given on the nature of alcoholic drinks and narcotics.

This is not an attempt to be funny or to denigrate any of the statutes, but it is doubtful if present-day students would be very highly motivated by a teacher who discusses alcohol in terms of its being *evil*, or by an hour or so of teaching on a day in January. In regard to the latter, a single unit or syllabus on alcohol not only is of dubious value, but may even be harmful. Plaut, for example, found that such one-shot efforts "may actually reinforce emotionally-charged attitudes. . ." (24, p. 156).

Whether the teaching consists of a single hour or is spread over the child's school life, it must consist of facts and open-end discussions, not sermons. We cannot expect to reach sophisticated teenagers, or even elementary grade students, if what we are saying is of dubious scientific validity, or if their actual experience tells them differently. There is little to be gained, for example, by not admitting that sensible drinking with friends can be a pleasant experience. Similarly, it is senseless to try to tell young people that for centuries people have been drinking only because they want to "show off" or because they are immoral. Obviously, there are individuals who drink for these reasons, but a worldwide custom as popular as this must have stronger roots. Globetti, for instance, postulates "that customs do not survive and diffuse from their point of origin unless they give man some satisfaction or unless they meet one of the imperative ends of the system." (10, p. 10)

Regardless of the fact that statutes do not always result in the best alcohol education, at least they do not forbid such teaching. There is a question, however, as to whether one can feel free to teach students how to drink sensibly. Certainly, it would not be easy. Schools are governed by local school boards, which tend to shy away from new programs, especially when those programs are thought to involve moral and behavioral changes. Programs are much more likely to be acceptable to the school board and the community if they are aimed at non-drinking rather than at sensible drinking.

Furthermore, many classroom teachers are not well trained to help students make behavioral choices. The teachers themselves are often in the position where their right to drink is not accepted by the general public. Thus, teachers are often effectively kept from drinking or must drink covertly. Under such a situation, their attitudes cannot help but become slightly warped, and they will find it very difficult not to let their own problems interfere with efforts to develop sensible behavior habits in students.

It should be mentioned here, however, that the development of 'sensible' behavior patterns is treading on dangerous ground, since our idea of what is sensible may be, and very likely is, very different from what young people think it is. However, in suggesting sensible driving habits, we are on safer ground than in prescribing, for example, sensible dress codes. At least we have some facts and figures to attach to what we say about what happens when one does not drive sensibly, or if one drives after not drinking sensibly.

An interesting corollary to drinking sensibly, and one that provides an alternative if the young person does not wish to drink at all but still has the youthful desire to experience something of what his drinking or drug-using peers are feeling, has been explored by a number of writers. Jacobson, for example, suggests that students can achieve the desired state of euphoria by learning about non-chemical "highs" such as: maintaining an optimal sensory input into the brain by such modalities as enjoying music, people, and nature; extending one's self in enjoyable physical activity such as mountain climbing, hiking, and bicycle-riding; helping other humans; and finally, loving and being loved (14).

But all of this has long been known in educational circles. Successful teaching always seems to involve participation, a good climate for learning, and good self-identity on the part of both teacher and pupil. There have been many teaching suggestions, plans and ideas that have been promoted in the past several decades alone. It is worthwhile discussing a few of the outstanding individuals who have promoted or repromoted these ideas.

McCarthy, for example, stripped away a lot of the misconceptions about how much drinking was actually being done by high school students (21). Witherill produced a sound alcohol education curriculum for the U.S. Department of Transportation (31), as well as a teaching manual for the American Driver and Traffic Safety Education Association (32). Waller stressed that students must be made to understand that alcohol affects the beginning drinker more forcefully than it does the adult, and that it is especially hazardous if the beginning drinker is also a beginning driver (29). Pelz and Schuman wrote about motivational factors (25), and Schuman tried to strip away the common myths that interfere with alcohol education (26). Zylman urged that we preserve our credibility with young people by a more careful use of drinking and driving statistics (33).

The vast extent of Chafetz's work, as is true of many of the authors listed here, cannot be capsuled in a sentence or two, but he strongly supported the teaching of young people to drink sensibly, and urged that such teaching be a part of education about living and coping with life, rather than be confined exclusively to drinking and driving (7). Hochbaum wrote extensively about the contradictions in the standards we try to teach as compared to those we practise (11). In addition, he emphasized that behavior modification occurs *within* the individual, that it is not something that *is done* to him; and like Zylman, pleaded for a healthy skepticism about reasearch in this field (34). Keller reminded us that young people emulate adults, and that we do not always provide the best example for them to emulate (16).

Mann developed extensive teaching ideas in the driver education field, urged the use of group dynamics (18), and argued strongly for the necessity of lengthening the traditional "30 and 6"[2] driver training courses (19). Alexander and Campbell gave us valuable information about peer influences (1). Maddox zeroed in on "typical" adolescent attitudes (20). Klette pointed out that, from the learning point of view, there is more success in using sanctions that are directed at providing alternatives than those that are aimed only at preventing wrong behavior (17).

---

[2] "30 and 6" refers to the standard High School driver education course of 30 hours of classroom work and 6 hours of practical driving.

To all of these, we could add a large number of valuable teaching aids produced by governmental agencies (8), by universities (10), and by private organizations (2, 3). The list could be continued for pages, but this should be sufficient to indicate that if alcohol education is not successful, it is not through lack of suggestions.

While the vast amount of work done in this field obviously cannot be effectively summarized, a brief guideline for school drug education programs developed for the California State Board of Education seems to include, to some extent, much of what most experts feel should be done in alcohol education (6). It suggests, for example, that drug education should start at the kindergarten level; that it be provided throughout the year, and that it be taught in all relevant subject areas; that it take in and cooperate with parents and community; that special teacher training be undertaken to develop knowledge and skills for this difficult task of behavior training; and finally, that counseling be available. It is not assumed that the California guideline is the best there is, or even that it is as adequate, for example, as the aforementioned Witherill document (31), but in a few pages the California guideline provides an excellent distillation of what most experts in the field have been proposing.

This vast amount of alcohol education material is chiefly concerned with formal teaching. Our proposals, on the other hand, relate to what the government, the community, the parents and all of us can do to improve the alcohol education of our young people. However, there is some discussion on school education in the first four of the following eleven proposals.

The proposals are as follows:

1. *Abolish the conventional grading system in alcohol education courses.* The examinations now used cannot effectively measure attitudes or behavioral characteristics. In fact, such testing may cause students to select and remember only the factual information, and that only long enough to complete the course. Students must, of course, learn some facts in order to engage in intelligent decision making, and this can be tested in the conventional way; but this in no way shows whether students who choose to drink have integrated what they have learned into a lifestyle which includes sensible drinking. The only way a fair grade can be given is to evaluate their lifestyle years later to see if their earlier education really did take. While this type of research would be extremely difficult and costly, alcohol education as presently practiced is also costly, especially since it may not be producing the desired results.

2. *Teach students how to drink sensibly!* This is meant literally, although it may lead to apoplexy in some parents and school board members. We do not have a modus operandi for providing such an educational effort, but obviously it would require a huge public relations effort in the community. But we must do it, because any student who elects to drink will indulge in experimentation. He will do it with or without supervision, and possibly hazardously.

Experimenting, of course, is natural. There is not much value in explaining that quite a bit of experimenting with alcohol has already been done, and that young people are simply engaging in a duplication of effort – most young people understand this. They know, for example, that they cannot ‘swill down’ a barrel of alcohol and expect to drive safely or even to live very long; but most of them must discover for themselves that alcohol does indeed do what we say it does. Everyone feels that he is different, and many feel that they are unusual as far as alcohol consumption is concerned; so experimentation is not about to be eliminated. Along this line, we must not denigrate the pleasant aspects of drinking – this is the surest way to lose our young audience.

Serving liquor to young people experimentally may be difficult, complex, and even illegal in some areas, but perhaps it could be done under some parental control system. Concerned parents and teachers in the community, knowledgeable in the effects of alcohol, might serve as leaders in establishing some experimentation patterns for youthful drinking that are acceptable, reasonable, and, most importantly, aimed at fostering sensible decision making concerning drinking. Some years ago "teen centers" were quite popular. Many now seem to have disappeared, some due to rowdyism, but most due to lack of continued interest and support by the community. In many of our communities, the restless teenager complains that he has nothing to do. This is debatable from the adult point of view, but it is true as far as activities that the teenager considers interesting are concerned. Communities must be awakened to the fact that a certain amount of drinking occurs simply because of boredom, but as was pointed out earlier, Jacobson and others suggest numerous alternatives (14).

3. *Improve driver training.* Despite the fact that there is adequate evidence that "growing-up" causes more trouble on the highway than lack of mechanical ability or knowledge about driving, the connection between beginning drivers and beginning drinkers is hardly a coincidence. Furthermore, it seems logical that a bit more ability to handle the vehicle might enable a drinking driver to avoid a crash that a driver with less ability could not. As pointed out by a Wisconsin driver instructor, Gesteland (9), students who have received night driving instruction, which most do not, would be better able to cope with reduced visibility problems at night, which, of course, are exacerbated by drinking.

It may well be that adding some simple things to the driving experience may do more good than anything else: driving on a skid pan until anti-skid steering becomes natural; driving on expressways; driving during rush hours; panic stops; and the like. Forget this 30 and 6 nonsense – make it a year-long for-credit course, with perhaps 15 or 20 hours behind the wheel. As far as commercial driving schools are concerned, the controversy will no doubt continue, although a California study (5) seemed to show that they could do as well or better than the high schools. Whether or not commercial driving schools can do a better job on the mechanical aspects of driving, it's dubious if they can do the behavioral task that needs to be done.

4. *Have students participate in developing alcohol education curricula.* Direct involvement in the planning stages of curricula would certainly go a long way in their acceptance. Teachers can learn a great deal about what students think and feel, and this is imperative if we are concerned with changing attitudes.

Students might be asked to do preliminary research on the materials to be included in the course. In addition, they could serve as discussion leaders in the classroom. There is some evidence that youngsters are sometimes more impressed, in a teaching situation, by their peers than their adult instructors (22). Such a learning experience would not only convince the youth of his importance in the educational system, but would afford him the opportunity to learn some new information by methods other than being 'talked at'.

5. *Lower, or eliminate entirely, the legal drinking age.* There is evidence to support the belief that laws are not an effective deterrent to early experimentation with alcohol (27). And even more vital to this discussion, we would be hard-pressed to support the premise that enforcement of existing minimum age laws alters behavior in regard to youthful drinking.

Most youngsters usually have their first drinks at home under parental guidance and long before the legal drinking age. Enforcement of minimum age laws that affect youth *after* they have been exposed to alcohol seems to reinforce the ambiguities that surround the entire area of alcohol education.

Lowering the legal drinking age to below 16 would have little direct effect on the driving situation, but it might take away some of the attraction of obtaining something that's illegal. In addition, as Jahoda points out, we would be helping to weaken the attractive link that children tend to see between consumption of alcohol and maturity (15). It seems possible, also, that the youngster drinking legally and with social acceptance at 14 or 15 might get some of the "newness of drinking" out of his system by the time of his first extensive automobile driving exposure.

Some early investigations conducted in states that have reduced the legal drinking age from 21 to 18 indicate that this change has resulted in an increase in alcohol-related arrests in this age group (30). While this initial increase may be true, we must not be too quick to assume that this change in the law will necessarily be harmful in the long run. We must remember, too, that with this change in the law, there were accompanying changes in detection methods to account for some of the increased arrests. Of course, by adding a larger number of drinkers, we should expect to have a certain increase in abusive drinkers. Let us hope that the early, and perhaps over-enthusiastic, reaction to this new-found freedom levels off.

6. *Remove the driver's license of an alcoholic or problem drinker who has been judged guilty of driving while intoxicated.* The license should not be reinstated for at least a year, or until the driver has been rehabilitated. If we can require an epileptic to wait a year or more to drive after an episode, why can't we do it to alcoholics or problem drinkers, who are certainly a more serious hazard on our highways? In fact, Illinois requires drivers with epilepsy to provide the Illinois License Agency with a physician's report attesting to freedom from an episode every three months (13).

While comparatively few young people are in the alcoholic category, and this proposal to remove licensure of alcoholics does not seem to have much connection with changing the role of youth on our highways, it should help to point out the disease aspects of alcoholism and help to give adults more credibility when talking about the seriousness of abusive drinking followed by driving. It would also serve to emphasize the need for treatment, rather than mere arrest and incarceration, which cannot cure alcoholism.

7. *More and better alcohol education research must be carried out.* Alcohol education to make safer drivers is a legitimate goal, but alcohol education to develop a sensible attitude towards drinking is quite different and requires different and undoubtedly sharper evaluation tools. In this type of research, complex behavioral changes must be measured. If we agree that in teaching alcohol education we are teaching a way of life, then our evaluation of success or failure must be far different from merely counting how many persons do or do not drink. In fact, any new research may be futile unless evaluation techniques are altered to take into consideration the goals, short and long-range, that we wish to realize through alcohol education.

8. *Attempt some alcohol education at the time the student receives his license to drive.* While alcohol may not be the primary culprit in auto crashes among youth, when added to the younster's overexuberance and inexperience in driving, it cannot be overlooked. Licensing agencies have a stake in the educational process, and they should consider a special effort to relate the issuance of a license to drive with the applicant's attitudes about drinking and driving.

9. *Begin alcohol education at the kindergarten level, and make it part of total health education teaching.* There is some evidence that children as early as ages four

and five can recognize alcohol by smell, shape of bottle or even, in some cases, by taste (15). Certainly, it is a rare child who reaches the mid-elementary grades and does not already know quite a lot about alcohol. Perhaps much of the information is incorrect and undoubtedly emotionally-based. This is why, as pointed out by Unterberger, alcohol education should be viewed essentially as re-education. (28)

10. *Involve parents, teachers, and other adults in the community in corollary alcohol education courses.* Parents will be much more willing to accept new innovative teaching programs if they know and understand them. Providing parents with the same information that is being taught to their children in the classroom would pave the way for intelligent discussions in the home, and this in itself suggests a change in the sometimes ambivalent approach to discussions of this sort. In fact, if parents and other adults had current, factual information, they might be much more willing to initiate discussions concerning alcohol and to alleviate some of the youthful apprehension that may lead to hazardous experimentation. Again, parents should be urged to admit that drinking can be pleasant, and that it *is* possible to drink and still drive safely. This will not cause youth to drink more, and it will give us a legitimate reason to criticize *excessive* drinking.

11. *Research the role of advertising and media programming in influencing youthful drinking patterns.* Almost as much emotionalism surrounds the entire area of the role of the media in influencing attitude and behavior as it does alcohol education generally. However, concrete data are lacking and substantial research must be conducted to learn exactly to what extent this influence is present. There can be little argument, though, concerning the potential for education that can be realized through widespread use of the media, plus classroom work.

In conclusion of this paper on teaching philosophies and methods, the thought comes to mind that perhaps all of us are looking for answers that are too complicated and sophisticated – we have become too involved in the electronic age. However, there is a proposed remedy. A study released recently by the Vermont Department of Education suggests that a return to the one-room schoolhouse may be in order. The study showed that individuals who went to a one-room schoolhouse "liked school" and felt that it had been "almost an extension of their home life." (4)

We don't know if we can equate such an answer with good alcohol education or with the learning of sensible behavior patterns, but it does sound strangely similar to the ingredients of successful teaching we have proposed here, namely: participation, a good climate for learning, making the subject a part of the real world of living, and good self-identity on the part of the teacher and pupil. It might be well worth further investigation.

REFERENCES

1. Alexander, C. N. and Campbell, E. Q., Peer Influences on Adolescent Drinking, *Quarterly Journal of Studies on Alcohol*, 28, 444, 1967.
2. American Medical Association, *Alcohol & the Impaired Driver.* Chicago, Illinois, 1970.
3. American Medical Association, *Drinking and Driving.* Chicago, Illinois, 1971.
4. Bissor, P., *Education: Right or Privilege.* Vermont Department of Education, Montpelier, Vermont, 1974.
5. California Department of Motor Vehicles and University of California joint project, *California Driver Training Evaluation Study.* Los Angeles, California, 1973.
6. California State Board of Education, *Guidelines for School Drug Education Programs.* Sacramento, California, 1973.

7. Chafetz, M. E., Problems of Reaching Youth, *Journal of School Health,* 43, 40-44, 1973.
8. Cushman, W. D. *Alcohol and Traffic Safety – A Curriculum Framework for Driver Educators.* National Highway Traffic Safety Administration, U.S. Department of Transportation report DOT-HS-101-1-144, Washington, D.C., 1971.
9. Gesteland, N., Let's Teach Teenagers How to Drive When They Drive Most Often – at Night, *Traffic Digest & Review*, November, 1967.
10. Globetti, G., Pomeroy, G. S., and Bennett, W. H., *Attitudes Toward Alcohol Education.* Mississippi State University, State College, Mississippi, 1969.
11. Hochbaum, G. M., Behavior Modification, *School Health Review,* September, 1971.
12. Holmes, H., Alcohol Education in the Schools, *Traffic Safety*, July, 1970.
13. Illinois Vehicle Code S51 Ill. Anno. St.–5, 1972.
14. Jacobson, L. D., Ethanol Education Today, *Journal of School Health*, 43, 36-39, 1973.
15. Jahoda, G. *Children and Alcohol.*, Her Majesty's Stationery Office, London, England, 1972.
16. Keller, W. K., Physical Health is Not Enough!, presented at 15th Annual School Health Session, American Medical Association, New York, N.Y., June 24, 1973.
17. Klette, H., Alcohol and Aging. In *National Conference on the Aging Driver Proceedings.* American Medical Association, Chicago, Illinois, 1974.
18. Mann, W. A., Using Group Dynamics for Better Driver Education. In *Personality Factors in Driver and Traffic Education* (course no. ED429J), Michigan State University, East Lansing, Michigan, 1968.
19. Mann, W. A., Difficulties in Changing Human Behavior. In *Personality Factors in Driver and Traffic Education* (course no. ED429J), Michigan State University, East Lansing, Michigan, 1968.
20. Maddox, G. L., Adolescence and Alcohol. In *Alcohol Education for Classroom and Community – A Source Book for Educators*, R. G. McCarthy, (Ed). New York, N.Y. 1964 Chapter 2.
21. McCarthy, R. G., High School Drinking Studies. In *Drinking and Intoxication*, R. G. McCarthy, (Ed) New Haven, Connecticut. 1959. Chapter 15.
22. Peer Approach to Prevention, *Alcohol Health and Research World.* Spring, 1974.
23. Phoenix Alcohol Safety Action Project, *A Knowledge and Opinion Survey of Phoenix High School Students About Drinking and Driving.* Phoenix, Arizona, 1974.
24. Plaut, T.F.A. *Alcohol Problems – A Report to the Nation by the Cooperative Commission on the Study of Alcoholism.* Oxford University Press, London, England, 1967.
25. Schuman, S. H., Pelz, D. C., Ehrlich, N. J., and Selzer, M. L., Young Male Drivers, *The Journal of the American Medical Association* 200, 1026, 1967.
26. Schuman, S. H., Drug Perception and the Student-Teacher Gap, *The Journal of the American Medical Association* 216, 659-663, 1971.
27. Sterne, M. W., Pittman, D. J., and Col, T., Teen-Agers, Drinking, and the Law: A Study of Arrest Trends for Alcohol-Related Offenses. In *Alcoholism*, D. J. Pittman, (Ed) New York, N.Y. 1967. Chapter 5.
28. Unterberger, H. and Di Cicco, L., Alcohol Education Re-evaluated, *Bulletin of the National Association of Secondary School Principals,* 52, 15-30, 1968.
29. Waller, J. A., Suggestions for Educational Programs About Alcohol and Highway Safety, *Traffic Safety Research Review* September 1968.
30. Williams, A. F., Rich, R. F., Zador, P. L., and Robertson, L. S., *The Legal Minimum Drinking Age and Fatal Motor Vehicle Crashes* (pre-publication copy), Insurance Institute for Highway Safety, Washington, D.C. 1974.
31. Witherill, J. W., *School Alcohol Education K-12 Curriculum Guide.* University of Wisconsin, Madison, Wisconsin, 1972.
32. Witherill, J. W., *People Do Drink and Drive.* American Driver and Traffic Safety Education Association, Washington, D.C., 1973.
33. Zylman, R., When It Became Legal to Drink at 18 in Michigan: What Happened?, *Journal of Traffic Safety Education* 21, 15-16, 34, 1974.
34. Zylman, R., Youth, Alcohol and Collision Involvement, *Journal of Safety Research* 5, 58-72, 1973.

Experimental Evaluation of a Community-Based Campaign Against Drinking and Driving

J. Pierce,[1,2] D. Hieatt, M. Goodstadt, L. Lonero, A. Cunliffe and H. Pang

Drinking-driving education programs have not succeeded in reducing the high rates of alcohol-involved collisions on our roads. Not only has potential benefit been lost and money wasted, but much of the enlightenment which could have been gained from these programs has been lost, due to the lack of research-based evaluation of program effectiveness. This shortcoming is of great concern to us at Safety Research and Development Section of the Ministry of Transportation and Communications for two reasons: 1) the magnitude of the drinking-driving problem in Ontario (where 50% of dead drivers were impaired or had been drinking and more than 27% of all fatal collisions had alcohol as a factor); and 2) the large amount of resources that are traditionally expended on apparently ineffective drinking-driving countermeasure programs.

In general, attempts at evaluating road safety programs have been less than ideal. Up to the present too many evaluations in this area have depended solely on post-program assessments or, at best, have used pre- and post-program measures. Without the use of comparison or control groups, or without the use of statistical procedures such as time series analysis, valid conclusions concerning program effectiveness are impossible. This means that some essential improvements in these programs were probably not made and that many innovative approaches were left undeveloped, all due to inadequate research design.

Drinking-driving education programs can be aimed at bringing about changes in attitudes, increases in knowledge and changes in actual behaviour. Questions pertaining to the evaluation of such programs include: Has any change occurred? What is the magnitude of the change? And was the change a direct result of the program? Programs which combine several types of countermeasures are more difficult to evaluate because we also need to know the differential effect of each component of the program. (For example, a mass-media education campaign may be run in conjunction with police spot checks.)

In this paper; we would like to demonstrate the usefulness of experimental design in traffic safety research by describing our recent effort to implement a pre-test/

[1] Ministry of Transportation and Communications, Downsview, Ontario, Canada.

[2] Acknowledgement: We are most grateful to Terry Smutylo for his large part in the preparation of this paper.

post-test control group design to evaluate a mass-media drinking-driving campaign in Ontario.

PROBLEMS IN PROGRAM EVALUATION

We would like to discuss several factors which could jeopardize the validity of conclusions concerning the effectiveness of such a campaign.

First, there is the problem of historical events which can deflect or augment the effect of a program or can confound its apparent results. For example, a roadside breathalyzer survey finds a high percentage of drivers with alcohol in their blood stream. Subsequently, a six week drinking-driving program is launched to counteract this situation. At the end of the program, the researchers find a significant reduction in the number of impaired drivers on the road but, unfortunately, they cannot tell whether this was a result of the campaign or whether it was the result of the brewery strike which began during the drinking-driving program.

Second, with a pre-test, post-test design, pre-testing itself may increase the sensitivity of the population to the program. People interviewed in a pre-campaign sample may pay greater attention to the subsequent safety program and learn more from it than people who were not interviewed. If the same sample is used for both pre- and post-program evaluation, the results could show a level of program effectiveness that was greatly exaggerated by the pre-test. The effectiveness of the actual campaign without pre-testing would remain unknown.

A third factor which can confound program evaluation is variation in instrumentation. That is, if the post-program survey is conducted in any way differently from the pre-program survey this difference may be confounded with, or mistaken for, results of the actual program. For example, a well-meaning researcher may change questions for the post-test in an effort to improve the questions. Or different interviewers may elicit conflicting responses from the same sample of respondents.

Finally, in the selection of samples, it is important that the pre- and post-samples are homogeneous with respect to relevant variables. Differences in the actual samples may be confused with results of the campaign unless special treatment is given to the data.

In evaluating traffic safety programs, most of these difficulties can be overcome through the utilization of a pre-test post-test control group design.

We would like now to discuss our countermeasure program, which utilized the pre-test/post-test control group design, in hope that the discussion may encourage the use of more effective evaluative tools in traffic safety research.

THE ONTARIO EXPERIENCE

In December 1973 the Ministry of Transportation and Communications, in cooperation with the Addiction Research Foundation of Ontario, ran a pilot drinking-driving campaign in nine Ontario cities. A control group of nine other cities was matched with the campaign cities and pre- and post-campaign telephone surveys were run in both groups of cities.

Implementation of the campaign stressed citizen involvement and community action in dealing with drinking-driving problems. In general, the campaign media material featured a positive approach to the drinking-driving problem, encouraging the use of alternative transportation and suggesting drinking limitations for those who will continue to drive after drinking. In addition, much of the material that was disseminated informally or prepared locally was concerned about the laws, penalties and consequences of impaired driving.

Selection of Cities

The 18 cities used in the pilot program were chosen and grouped on the basis of four criteria: total population, geographic distribution, radio overlap and rate of drinking-driving collisions.

1. The population receiving the campaign was chosen to be as large as possible and approximately equal to the combined population of the cities in the control group.

2. Both groups were chosen to be geographically representative of the most highly populated areas of Ontario (Figure 1).

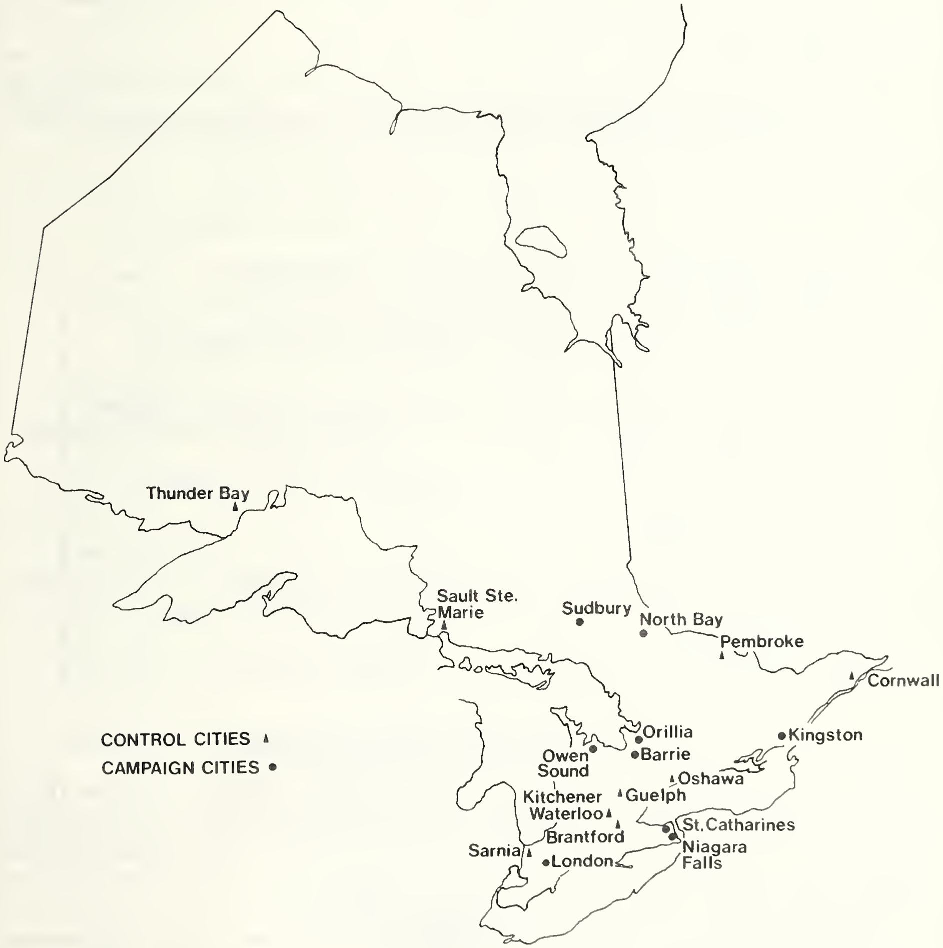


Figure 1 *Ontario map showing distribution of campaign and control cities.*

3. Radio broadcast areas of the campaign cities had a minimum of overlap with the control cities.

4. The per capita rates of alcohol-involved collisions were approximately the same for both groups of cities.

By choosing several cities to receive the campaign instead of just one, and by distribution of both campaign and control cities geographically over the province, we hoped to average out any historical or seasonal influences. Without a control group, factors such as a fuel shortage, a severe winter or the generally heightened awareness of the drinking-driving problem during the Christmas holiday season would be confounded with the effects of the campaign.

Evaluation

A telephone survey questionnaire was the sole source of data used for this evaluation. While it would have been desirable to directly monitor drinking-driving behaviour this was impossible due to severe time constraints.

The data for the evaluation were obtained from the telephone surveys which were conducted in all the cities both prior to the campaign in November 1973 and after the campaign in January 1974. The sample sizes for the four surveys are shown in Table I.

TABLE I *Number of Persons Interviewed in Each of the Four Surveys*

TIME OF SURVEY	LOCATION OF SURVEY	
	Campaign Cities	Control Cities
"BEFORE" the Campaign (in November)	1122	1053
"AFTER" the Campaign (in January)	1120	1054

The people chosen for the samples were randomly selected from the file of licensed drivers of the Ministry of Transportation and Communications. To encourage co-operation, each person selected was sent an advance letter informing him that he would be called upon for an interview. Ninety-five per cent of all persons contacted completed the questionnaire which took 10 to 15 minutes.

Since the pre- and post-campaign samples were chosen without replacement (that is, they represented independent samples) there is no problem with pre-test sensitization.

In order to avoid the problem of instrumentation effects, the same local interviewers in each city conducted both pre- and post-campaign interviews using a standard questionnaire.

Although precautions may be taken in the planning stages to ensure that random samples of persons will be surveyed, in practice you cannot be sure that the method of selection will yield strictly comparable samples.

Thus, in our telephone survey questionnaire we obtained basic demographic information, that is, age, sex, marital status, education and occupation; information on car ownership and miles driven; reported drinking behaviour; and exposure to radio and newspaper. This we felt was adequate background information to determine whether or not the samples were sufficiently homogeneous for the required comparisons.

Analysis shows that the four surveys were homogeneous with respect to most of these variables. There were some statistically significant differences in education, occupation, and miles driven. Figure 2 shows the distribution of miles driven for the four samples.

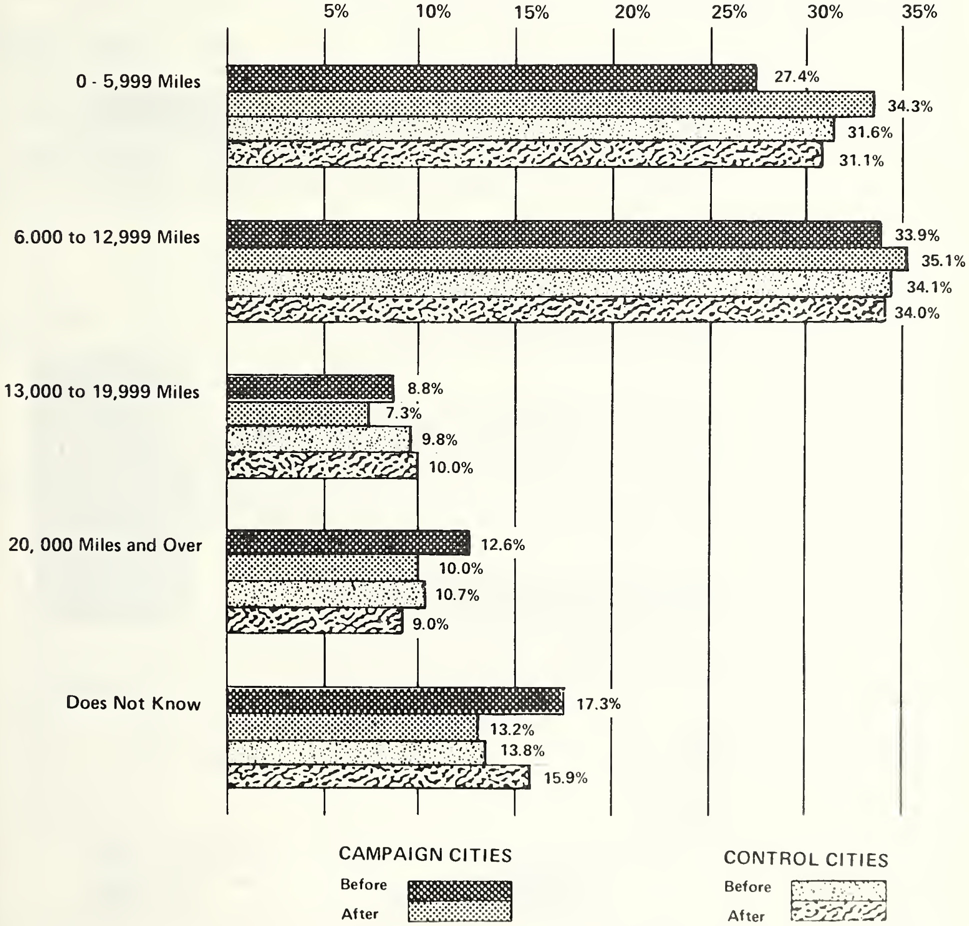


Figure 2 *Reported number of miles driven in a year by licensed drivers.*

There seemed to be a slight deficit in persons reporting low mileage in the pre-campaign sample from the campaign cities. This difference is small and balanced by an excess of responses "Does not know", so we continued under the assumption of no difference with regard to this variable.

The differences in education and occupation were related. The post-campaign sample in the campaign cities had a slight excess of college educated people and people in professional occupations. The analyses which follow took into account these differences.

Because there is so little information available on drinking behaviour, the reported drinking behaviour of the people surveyed is included here.

We asked: "How many drinks of alcoholic beverages do you yourself usually drink in a week? Would you please tell me the number and kinds of drinks?" We tabulated the number of drinks of Beer, Wine, Mixed drinks or Cocktails, and Brandy and Liqueurs. The distributions of drinks of each of these types were homogeneous over the four samples. The total number of drinks of all kinds is shown in Figure 3. We see that about 30% of the people surveyed reported that they drink only occasionally or not at all, while over 20% reported averaging more than one drink per day. It was encouraging that the refusal rate for this question was only 3%.

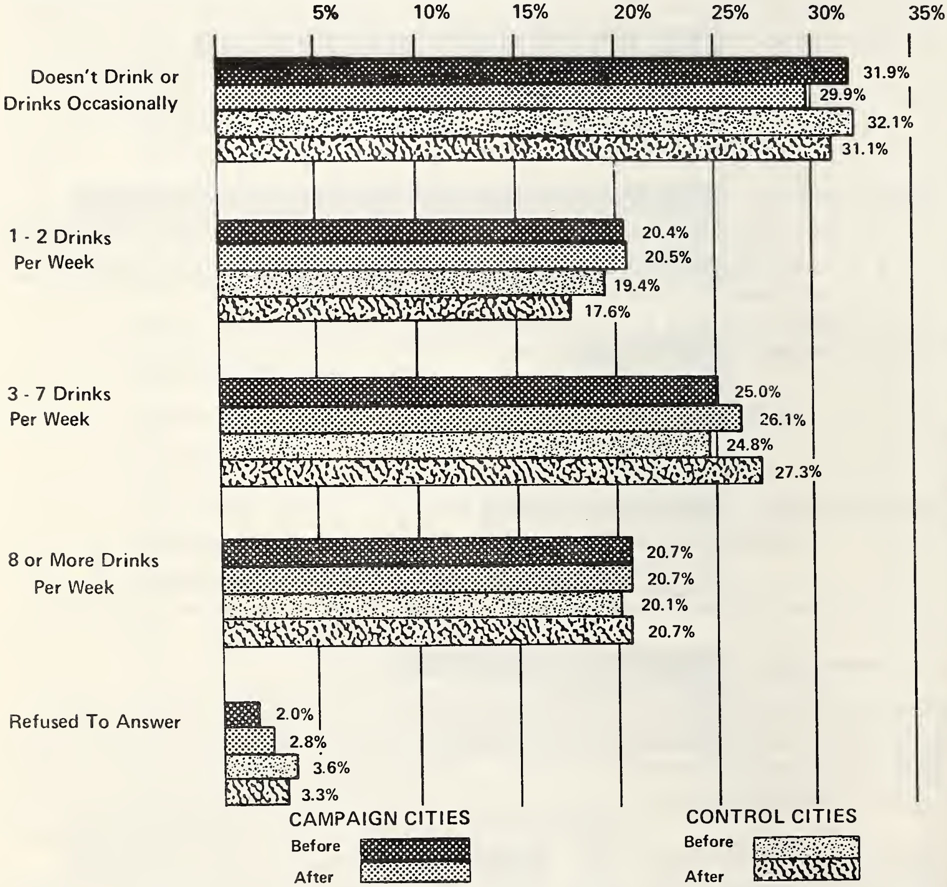


Figure 3 *Reported number of drinks of alcohol beverages usually consumed in a week by licensed drivers.*

RESULTS

There are several levels at which we can determine the effectiveness of our campaign.

1. Did the campaigns reach the population?
2. Did people's opinions change?
3. Was their knowledge increased?
4. Did the campaign cause a heightened awareness of the problem to the extent of influencing people to talk about it?
5. Was there a change in reported behaviour?

Let us look at a few results from the telephone survey to see some areas where we were successful and some areas where we were not successful and in the process show why it was essential to have a control group of cities for comparison.

While reaching people is an essential aspect of any campaign, the ultimate judgment of the effectiveness lies in the changing of their behaviour. We will look at two of the questions on the survey that are measures of reported behaviour.

> *During the last month have you encouraged someone not to drive home because he or she had drunk too much?*

In the campaign cities, before the campaign, 19% of the people surveyed answered yes and after the survey 25% said yes. This increase is statistically significant. But, as we see in Figure 4, the control cities experienced an almost identical increase. So, the control cities showed us that the observed increase in the campaign cities was not necessarily due to the campaign but came about naturally in the course of the holiday season.

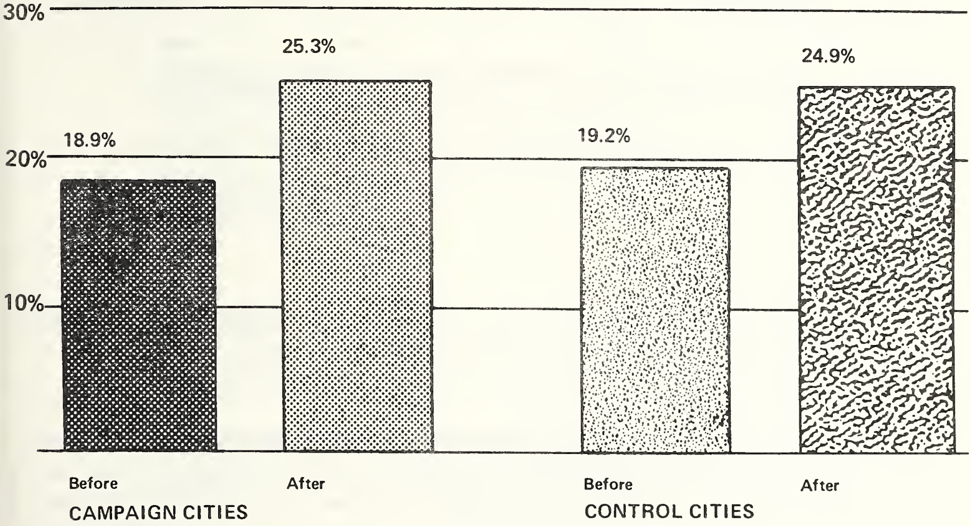


Figure 4 *Per cent of persons surveyed who responded "Yes" to the question: "During the last month have you encouraged someone not to drive home because he or she had drunk too much?"*

Another question we asked was:

> *During the last month have you not driven home because you had drunk too much?*

Only a few of the interviewees answered affirmatively before the campaign (47 or 4.2%). This number doubled to 8.5% after the campaign and represents a statistically significant increase. Can we attribute this increase to the campaign? In Figure 5 we see that the answer is yes. While the control cities did experience a slight increase, it was not significant and was small in relation to the increase in the campaign cities.

Although the number of persons who changed their behaviour seem trivially small we feel encouraged that apparently we were able to make some inroads in this very difficult area of changing behaviour.

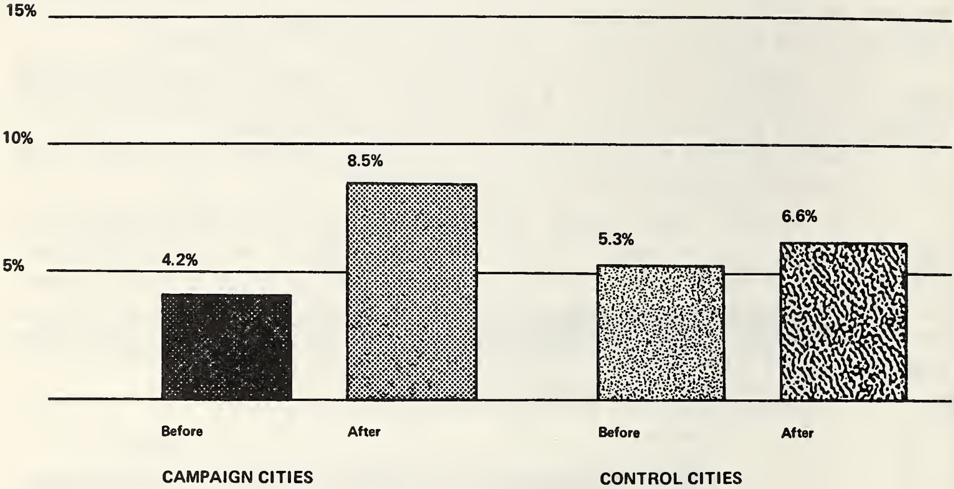


Figure 5 *Per cent of persons surveyed who responded "Yes" to the question: "During the last month have you not driven home because you had drunk too much?"*

Another level at which behaviour can be changed is in influencing people to talk about the subject with others. In our telephone interview we asked:

Did you talk to anyone in the past month about drinking and driving?

In the campaign cities there was a statistically significant increase of 15 percentage points from before the campaign to after the campaign of those who said they talked about Drinking and Driving. In the control cities there was a statistically significant increase of 7 percentage points (Figure 6). It turns out that the increase in the campaign cities is significantly greater than the increase in the control cities so we can claim that the campaign was responsible for increasing the amount of conversation about Drinking and Driving. Another level of effectiveness is the increasing of knowledge about drinking and driving. Figure 7 shows the responses given to the question:

What is the maximum legal breathalyzer reading for a driver?

The campaign was effective in increasing the knowledge of the maximum legal Blood Alcohol Concentration.

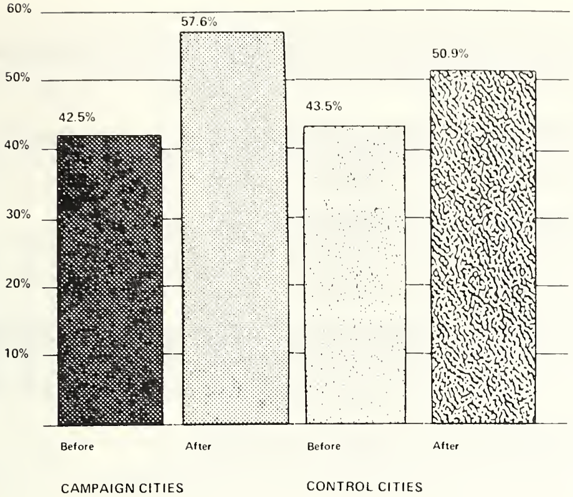


Figure 6 *Per cent of persons surveyed who reported having had a conversation with someone about drinking & driving in the previous month.*

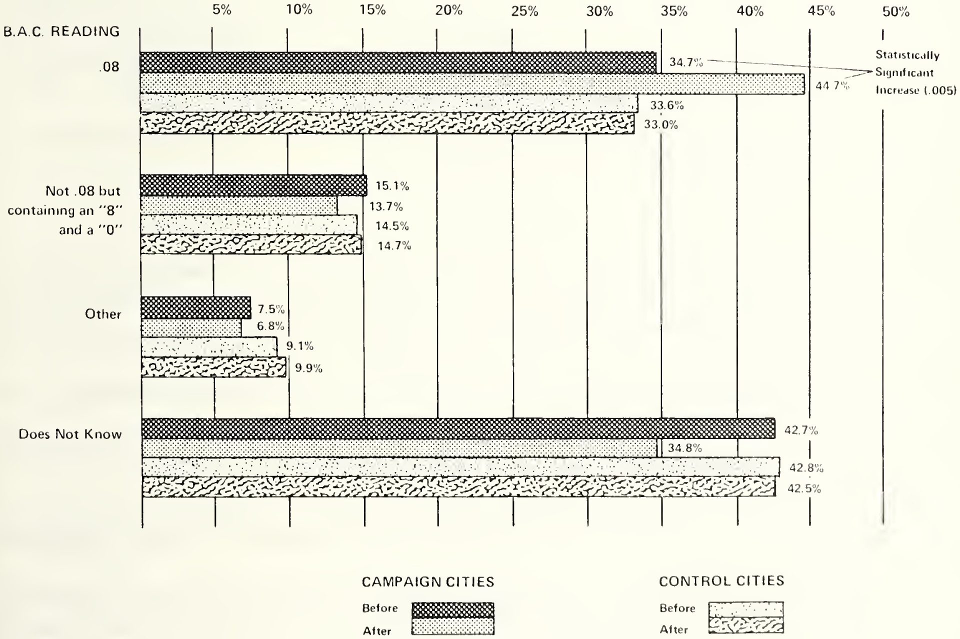


Figure 7 *Per cent of people surveyed who gave answers in response to the question: "What is the maximum legal breathalyzer reading for a driver?*

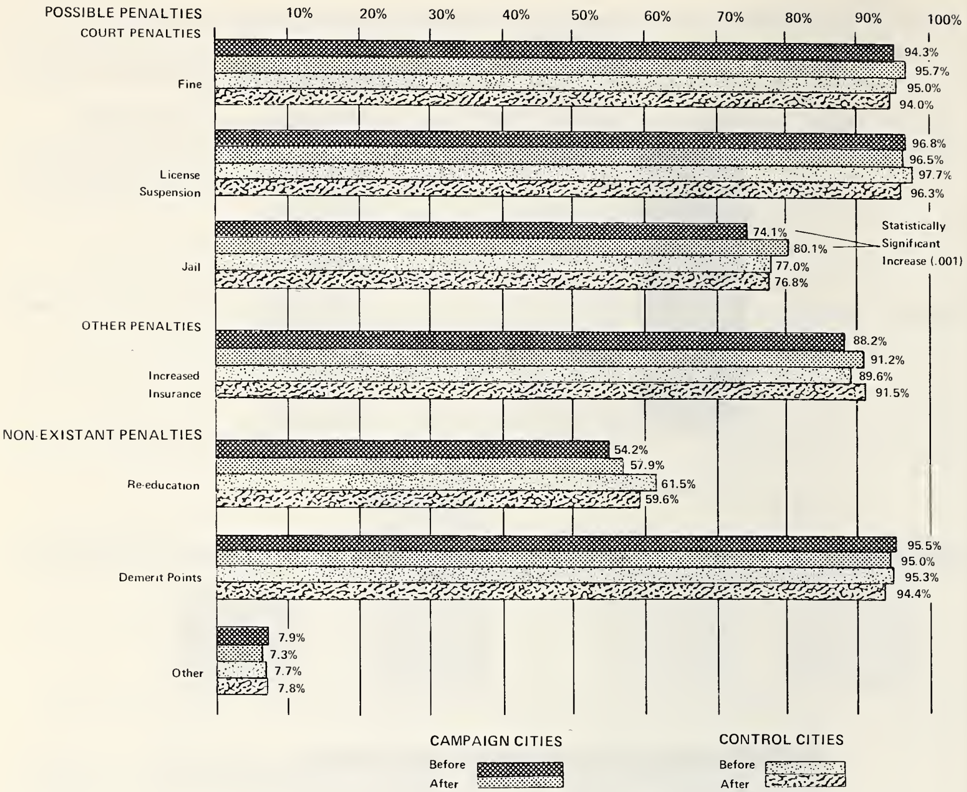


Figure 8 *Per cent of people surveyed who thought that the item listed could be part of a penalty for impaired or drunken driving.*

Another set of results that is somewhat interesting has to do with the penalties for drinking-driving offences and include not only those that exist and are part of the Court system or imposed by society, but also penalties which do not exist. Figure 8 shows us the following:

1. There was a small but statistically significant increase about knowledge of the jail sentence in the campaign cities.

2. There would appear to be a generally high level of knowledge of the actual formal penalties of conviction.

3. Many persons believe that they will incur other penalties that do not exist. This may indicate that people really do not know the penalties but simply guess that they are many and severe.

Then there is the question of changing people's opinions with respect to drinking and driving. We asked their opinions about whether or not the Courts were tough enough in giving out penalties for drinking-driving offences and whether or not more police resources should be spent in trying to catch impaired drivers. No changes were detected between any of the surveys with respect to the opinion questions. Overall, 67% thought the Courts should be tougher in giving out penalties but only 53% thought more police resources should be spent in trying to catch drinking drivers.

These results show, as do the recall and recognition questions in the survey, that the campaign material did reach the people. Further, some success was attained in increasing knowledge, and awareness relative to drinking-driving as well as in influencing reported behaviour.

SUMMARY

Through the use of a pre-test/post-test control group design we have been able to arrive at some valid assessments of the effectiveness of the different components of our drinking-driving campaign. There was some measure of success. The campaign was effective in increasing the number of people who reported not driving home when they were drunk; it informed people of the maximum legal blood alcohol level, and that jail was a possible penalty of drinking and driving; and it increased the number of conversations about drinking and driving.

By using two groups of 9 cities each, distributed over the most highly populated areas of Ontario, we managed to avoid the problem of historical and seasonal effects which often plague evaluative attempts. Other aspects of our particular pre-test/post-test control group design eliminated the common problems of pre-test sensitization, instrumentation effects, and lack of homogeneity among survey samples.

The success attained in developing effective traffic safety programs may depend on whether or not the concerned agencies integrate this type of research design with their countermeasure programs. Once we are able to exchange valid assessments of the effectiveness of our safety programs and their components, then we may make definite progress towards eliminating the traffic hazards presented by improper driver behaviour.

The Role of Attitudes in Secondary School Alcohol-Traffic Safety Education

Peter Finn[1]

Discussion of alcohol-traffic safety education can focus on many issues, including objectives, content, instructional strategies, subject area relevance, evaluation, student interests, teacher training, and community involvement. In this paper I want to touch on yet another aspect of drinking-driving education: the role of attitudes.

What attitudes? Attitudes toward alcohol-traffic safety education, toward drinking, and toward driving. Whose attitudes? Teachers', students', and school administrators' attitudes. Why attitudes? Answering this latter query constitutes the essence of this paper.

ATTITUDES TOWARD DRINKING AND DRIVING

We can begin to answer the question, "Why focus on the role of attitudes in alcohol-traffic safety education?" by considering the following data. Any survey of any typical audience will usually elicit a wide diversity of responses to the following two questions:

1. At what age should youngsters be permitted legally to drink alcohol in bars or purchase alcohol in package stores?
2. Should advertisements for whiskey, wine, and beer be permitted on television?

In response to the first question, comments will generally vary from stipulating no minimum age to a twenty-one-year-old minimum age. In answer to question two, recommendations will include permitting television ads for all alcoholic beverages, for just wine and beer, and prohibiting any ads for alcoholic beverages. Clearly the wide disparity in opinions reflected in the responses to these two questions points to the existence of a variety of underlying attitudes on the part of the respondents. Some examples of attitudes that may have given rise to these diverse opinions include the following:

Nobody should drink alcohol: abstinence is the only justifiable posture toward drinking because (a) drinking is sinful; and/or, (b) some, many, or all people who touch any alcohol will become alcoholics; and/or, (c) alcohol, even in moderation, is physiologically and/or emotionally damaging.

People should not drink because they will abuse alcohol; therefore, we must not promote alcohol use at all either through advertising or legalization for teenagers because these potential alcohol abusers, a relatively small group though they may be, will be unable to resist the blandishments of the advertisements and will abuse their access to legal alcohol. We must protect these weak-willed individuals, even though they may constitute a minority of society and of drinkers.

---

[1] Senior Education Analyst, Abt Associates Inc., Cambridge, Massachusetts

Alcohol use in moderation is perfectly acceptable – but why promote it? What adults and teenagers aren't aware of won't hurt them.

Allow people full access to alcohol; if they abuse it, that's their fault. Everyone is responsible for his or her own personal behavior, including drinking behavior. It's not up to society, including the media and legislators, to do the people's job of self-restraint for them.

People need to learn from "the school of hard knocks" about the positive and negative effects of alcohol. They can learn this information best through direct, personal experience, and such experience should therefore be permitted or even encouraged.

I am sure these are only a few of the many attitudes that form the basis of an individual's opinion that the drinking age should be 21 or 13 or that television advertising of alcoholic beverages should be unregulated or prohibited. But whatever the different attitudes toward drinking and driving are held, we maintain our beliefs about drinking and driving and take appropriate action in large part because of our attitudes. Teachers, obviously, hold opinions about alcohol-traffic safety and their beliefs, too, derive from attitudes toward drinking and driving. The problem for teachers, however, is that these attitudes may seep into their lesson plans and teaching and vitiate their best efforts to enable youngsters to make responsible decisions about drinking and driving.

Teacher Attitudes in the Classroom

How do these attitudes intrude into the classroom? The example with which we are most familiar and against which we most often inveigh is the teacher who advocates for his or her students abstinence as the only viable behavior toward drinking because alcohol is bad in any amount or because any amount of alcohol will impair driving ability. While this type of teacher attitude in the classroom is not uncommon, it is less harmful than other more subtly expressed attitudes because its very openness allows students to compensate for it – usually by dismissing it out of hand. More harmful teacher attitudes that creep into teaching practices include the following:

Hostility, jealousy, or fear toward students who drink or drink and drive, felt and expressed (overtly or covertly) by teachers who are not at ease with their own drinking and driving behavior, teachers who regret not having "sown their wild oats" when they were young, teachers who want to recapture their lost youth, or teachers who secretly would like to emulate the apparent freedom and lack of inhibition their students seem to exhibit.

The attitude that "moderate drinking is all right" as long as students accept the teacher's definition of moderate, which may be a glass of wine with dinner, or getting drunk with the boys (or girls) every Friday night, or any of a number of other drinking patterns.

The attitude that drinking and driving are personal decisions with which the teacher and public school system should not get involved, and "I'm teaching about drinking and driving only because I have to."

These are just some of the diverse attitudes teachers, like the rest of society, are likely to have about drinking and driving. Everyone is entitled to his own opinion and therefore having such attitudes, is appropriate. *Expressing them in the classroom,* I feel, is inappropriate. It is the thesis of this paper that teachers should remain entirely neutral in the classroom in terms of expressing views about whether their students now or in the future should drink, how much they should drink, and under what conditions they should drive.

There are two critical reasons why teachers must keep their attitudes toward drinking and driving to themselves when teaching about alcohol-traffic safety.

1. The first reason is that students should come to their own conclusions about drinking so that they learn the process of independent thinking, a skill that can then, hopefully, be transferred to other critical problems where responsible decision-making is essential. Telling students not to drive after one or ten drinks defeats the teaching objective of encouraging the development of effective and transferable decision-making skills.

2. The second reason why teachers must not allow their attitudes toward drinking and driving to intrude into their teaching is the more important one. It is that the expression of such attitudes *will destroy the teacher's chances of producing any rational examination on the part of students of how they should drink and drive.* Telling students what responsible drinking and driving behaviors are thought to be will not, by and large, produce such behaviors however various individuals define the term 'responsible'. Why can teachers not expect to produce desirable behaviors in youngsters by telling them how to behave? There are four reasons why expressly seeking to produce specific responsible drinking and driving behaviors in youngsters won't work for many, if not most, students.

First, as John Holt (7) and others have pointed out, many students want to get good grades in school because schools, including colleges, with their heavy emphasis on grades as the principal means of evaluating learning, admitting candidates, and awarding scholarships create this overriding academic concern in students. In addition, most teachers do not sincerely encourage students to disagree actively with their point of view, especially in a controversial area like drinking and driving. As a result, students who wish to get high grades tend to replay to teachers what teachers want to hear. Most teaching materials are of little help to teachers in the encouragement of open discussion. "Curriculum guides. . ." laments one teacher, "seem to encourage the feeding of canned information eliciting appropriate and often parroted responses from students." (3,p.13) Students become adept at supplying these responses and in the process may spend more time exercising talents of flattery and mimicry than in developing responsible attitudes toward drinking and driving.

A second reason why direct inculcation of drinking and driving attitudes will not succeed with most students is that today's youth tend to disrespect and 'tune out' the teacher who tells them what is right and wrong, because youngsters are finely attuned to the hypocrisy of how adult behavior belies adult precepts. They know that many teachers admonish them to behave one way but fail to live up to their own advice. For example, a double standard exists between secondary school athletic coaches, who tell their pupils and athletes not to drink or take other drugs because of alleged harmful effects drug use will have on athletic performance, and coaches of professional teams who encourage their players to take drugs. Professional athletes are routinely provided with cortisone for gaining weight, zylicane for killing pain, amphetamines for peak performance, and a host of other drugs forbidden to secondary school students on the grounds that they are dangerous, habit forming, or illegal. The message is clear: it is appropriate to take drugs when money is at stake. For example, a star hitter in baseball will have zylicane sprayed on his injured wrist so he can continue to play the game and help the team finish high enough in the standings to ensure a piece of the play-offs' financial pie. But it is totally unacceptable, the young student concludes, for him to take drugs since he is playing the game 'merely' for enjoyment. Taking drugs to make money is legitimate; using drugs to prolong the fun is not to be countenanced.

Moreover, students hear teachers warn them of the dangers of driving after drinking, knowing full well that many such teachers cannot wait until the class period ends to hasten to the teacher's room to puff on a desparately needed cigarette. The conclusion again is obvious: youngsters should not endanger their lives by drinking and driving, but teachers may risk theirs by smoking. Nor are youngsters impressed by the argument that smoking hurts only oneself, but driving after drinking endangers the lives of others. For, in fact, parents increase the risk of cancer and heart disease in their own children by smoking themselves, because youngsters, one or both of whose parents smoke, are much more likely to end up smoking themselves than are youngsters from non-smoking homes. Moreover, youngsters also listen to teachers admonishing them not to drive after drinking and then see these same teachers drive home with their seat and shoulder belts unused.

In short, youngsters have seen what they feel is too much adult hypocrisy to accept advice from teachers on how they should conduct their own lives. Adults have lost their unquestioned powers of command and moral suasion for a good part of the younger generation. The age of the teacher as a moral exemplar is over. Responsible drinking and driving behavior will not result, therefore, from teacher dictums on what to do and what not to do.

A third reason many students will not respond to teacher advice on how to drink and drive is that they are insulted by the teacher's implicit assumption that youngsters, given the facts and the opportunity to discuss their feelings, are too dumb to come to their own responsible conclusions about how to drink and drive – especially when, given the facts about seat belts, many adults are evidently unqualified to come to their own conclusions about safe driving habits. Most youngsters can, in fact, come to their own conclusions about how they should drink and drive as well (or poorly) as adults can. Condescendingly assuming they cannot only inclines them to ignore or actively reject the advice teachers give them.

Finally, and most importantly, teacher expression of their attitudes toward drinking and driving will not generally make students become responsible drinkers and drivers because it will discourage students from examining *their own* attitudes toward drinking and driving. Students will not examine their own attitudes when teachers express theirs because students will either parrot the teacher's opinions, reject the advice as coming from a source invalidated by hypocrisy, or rebel against the teacher's assumptions of student inferiority.

Student Attitudes in the Classroom

Now that I have stressed why it is important that teachers do not express their attitudes toward drinking and driving in the classroom, why is it so important that students *do* express *theirs*?

Students must be encouraged to express their attitudes because even the avoidance of advice-giving by teachers and an unbiased exposition of the facts about drinking and driving – that is, purely cognitive approaches – are often insufficient for producing desirable behaviors (1). For example, a study was conducted in which two communities in California were subjected to a barrage of data through the media on how using seat belts saves lives and reduces the severity of injuries in accidents. Evaluation of the results revealed that in one of the communities the extent of seat belt use remained the same, while in the second community it actually declined a little (8). So much for the efficacy of a primarily cognitive approach. Laziness is, of course, a reason for people not using seat belts. Also, it is clear that attitudes and feelings are more powerful for many, even most, people in determining seat belt use than knowledge of 'the facts'. What these attitudes are, in the case of seat belts, is not clear, but they may include public resentment at the attempt by the Government to direct their lives (not dissimilar to students' reactions to teachers who try to direct *their* lives), "it won't happen to me" thinking, and the feeling among some men that using seat belts is a sign of weakness and lack of masculinity. Similar attitudes underlie the motives people have for drinking to excess and then driving. Therefore, as several educators have stressed (6, 9), if we expect to motivate students to drink and drive responsibly *we must provide an atmosphere in which students can discover, reveal, discuss, and examine these attitudes.* The extent to which we succeed in creating such an atmosphere will be in direct proportion to the degree to which teachers keep their own attitudes out of the classroom.

However is this refusal of teachers to express their attitudes while encouraging students to reveal theirs not just one more example of teacher hypocrisy? Not at all. For the most effective method of dealing with student attitudes is for students to express and examine them not with the teacher but *with each other* in small group discussions and role plays (10). Small peer group discussions and role play exercises, if properly moderated (that is, not manipulated) are much more productive than so-called class discussions and certainly lectures in which, for the most part, the teacher leads the students to foregone conclusions by manipulating the direction and content of the talk. Small group discussions and role plays are effective precisely because the teacher is not covertly guiding the class and because many students respect and trust each other's expression of attitudes, even though they may disagree with them. More than class discussions and of course lectures, small group discussions and role plays permit an open expression of student concerns about drinking and driving, including the influence of peer group pressure, search for 'kicks' and danger, the need to emulate adults and feel grown-up, and 'it-won't-happen-to-me' type of rationalizations. An example of classroom activities that stress small group discussions and role plays is provided at the end of this paper (Appendix A).[2]

HOPES FOR THE FUTURE

I have stressed that teachers must refrain from expressing their attitudes toward drinking and driving in the classroom and that students must be motivated to reveal and examine theirs. In many schools neither of these two goals can be achieved unless school administrators explicitly and publicly support them. Many teachers feel they must publicly deplore all student drinking and driving after any drinking because they fear administration reprisal at worst and lack of support at best should parents claim they are, through their neutral stance, advocating the use of alcohol or driving after drinking.

---

[2] This Appendix is just one example taken from: Finn, P. and Platt, J., *Alcohol and alcohol safety. A curriculum Manual for Senior High Level*, Superintendent of Documents, U.S. Government Printing Office, Washington D.C., 1972, Volume II.

This is not the place to discuss how these three goals of teacher neutrality, student openness, and administration support for both can be achieved. Clearly, the involvement of parents and the community is essential in any such educational approach. It is also critical to train teachers to become aware of their own attitudes toward drinking and driving, to learn how to avoid letting their attitudes intrude into the classroom, to encourage students to express their attitudes, and to gain confidence that administrators and parents support their efforts.

Several years ago we were warned by Dr. Morris Chafetz, presently Director of the U.S. National Institute on Alcohol Abuse and Alcoholism, not to expect too much from secondary school alcohol education (4). We know, too, that to date there has been no convincing evidence that students who take driver education classes drive more safely than students who have not. In fact, there is little empirical evidence regarding the effectiveness of any of the different approaches to drug education that have evolved in the past several years (2). An approach to traffic-safety education, therefore, that emphasizes the suppression of teacher attitudes in the classroom, the exploration of students' attitudes, and the support of both these goals by school administrators and the community may permit us to raise our expectations of what can be accomplished in the schools and produce evidence that education can reduce the world's appalling number of alcohol-related traffic accidents and fatalities.

APPENDIX A

REFERENCE #: 1
CONTENT REFERENCE: 214-216
CLASS TIME: 1 period

ACTIVITY #: 17
TOPIC: Safety: interpersonal
METHOD: Discussion

Core Activity:

Students discuss best course of action to take if they are about to ride with a driver who has been drinking excessively.

Objective:

Students demonstrate knowledge of and ability to evaluate alternate responses to interpersonal situations involving alcohol use and traffic safety in order to make responsible decisions about drinking and driving.

Preliminary Considerations:

SKILLS DEVELOPED: Influencing, decision making.
OTHER: Students need to have already studied effects of drinking on driving.

Activity:

Students write brief (½-1 page) response to one or more scenarios in which a driver who has been drinking excessively offers them a ride. Sample scenarios are on the next page.

The following class, students break into small groups and are given written instructions to discuss:

- What they *would* do, how, and why
- What they *should* do, how, and why
- How any discrepancy between what students would and should do can be resolved.

Each group reports its conclusions to class and responds to questions and comments from class and teacher.

Variations and Supplementary Activities:

- Activity can be conducted as a class discussion or written homework assignment.

Evaluation Methods:

- Students role play or write the dialogue to these or to new scenarios in which individuals are offered rides by drivers who have been drinking excessively.
- Students write a "Handbook for Passengers" on how to respond to drivers who have been drinking excessively who offer them rides.

Sample Scenarios

You are just finishing up hockey practice and your brother has come to pick you up. He hates this task and you know it, but the rink is several miles from home. A taxi would be expensive and your father is working and your mother taking care of your brothers and sisters. This time your brother is roaring drunk but insists he's able to drive OK. You have about 25 cents on you. What *will* you do? What *should* you do? Why?

You and four friends have been drinking in the park. Three of them start walking home, but the one who owns the only car and is really drunk stays to drink a little longer with you. You live a good four miles away and there is no public transportation. You know your friend will insist he drive you home. You have about $5.00 on you. It is 2 a.m. What *will* you do? What *should* you do? Why?

You baby-sat tonight with three children while their parents went to a party. You need every cent of the money for new school clothes, so you don't want to take a cab. The lady, who is your mother's best friend, offers to drive you home. But she is so drunk she had trouble getting in the house at 2 a.m. What *will* you do? What *should* you do? Why?

New scenarios can be created by varying:

- the amount drunk by the driver
- the relationship between the driver and the rider.
- the amount of money the potential rider has, the distance to his home, and the availability of other forms of transportation.

REFERENCES

1. Aubrey, R. F., Drug Education; Can Teachers Do the Job? *Teachers College Record* 72, 417-422 (1971).
2. Braucht, N. G., Follingstad, Brakarsh, and Berry, K. L., Drug Education: A Review of Goals, Approaches and Effectiveness, and a Paradigm for Evaluation, *Quarterly Journal of Studies on Alcohol* 34, 1279-1293 (1973).
3. Caliguri, J. P., Drug Education Guides Are Not Enough, *Journal of Alcohol and Drug Education* 18, No. 2: 13-17 (1973).
4. Chafetz, E. and Demone, H. W. Jr., *Alcoholism and Society.* Oxford University Press, New York, 1962.

5. Finn, P. and Platt J., *Alcohol and Alcohol Safety: A Curriculum Manual for Senior High Level,* Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., Volume II, 1972.

6. Globetti, G. Alcohol Education in the School, *Journal of Alcohol and Drug Education* 1, No. 3: 3-8 (1971).

7. Holt, John, *How Children Fail.* Dell Publishing Co., New York, 1964.

8. Moore, L., National Highway Traffic Safety Administration, U.S. Department of Transportation; personal communication to the author.

9. DiCicco, H. and Unterberger, L., Alcohol Education Re-evaluated, *The Bulletin of the National Association of Secondary-School Principals* 52, No. 326: 15-29 (1968).

10. Williams, A. F., DiCicco L. M. and Unterberger, H. Philosophy and Evaluation of an Alcohol Education Program, *Quarterly Journal of Studies on Alcohol* 29, No. 3: 685 (1968).

Présentation d'une Campagne sur l'Alcool et la Conduite réalisée de Février à Mai 1974 en France

Jean L'Hoste[1]

L'exposé de la préparation et de la réalisation de cette campagne n'a nullement la prétention de proposer un modèle de ce qu'il convient de faire ou d'apporter des résultats rigoureux quant à l'efficacité de l'action entreprise; nous l'avons choisie en raison de son actualité et comme une source de réflexions théoriques et pratiques sur le rôle que peut jouer l'information du public vis-à-vis du problème de l'alcoolisation des conducteurs.

Pour mieux situer cette campagne, nous décrirons d'abord brièvement l'organisation générale des campagnes de sécurité routière en France.

Un organisme central interministériel, la Délégation à la Sécurité Routière, décide des thèmes qui seront retenus. En général trois thèmes principaux sont traités chaque année, par exemple en 1974: l'Alcool et la Conduite – Les Ceintures de Sécurité – La Sécurité des enfants piétons. La durée de chaque campagne est de deux à trois mois.

Les études préparatoires, qualitatives et quantitatives, sont prises en charge par l'Organisme National de Sécurité Routière qui dispose d'équipes d'ingénieurs et de Psychologues. Lors de la réalisation proprement dite de la campagne, la Délégation à la Sécurité Routière et l'Organisme National de Sécurité Routière assurent ensemble les contacts avec les agences de publicité, les réalisateurs de films, l'Office de Radiodiffusion et Télévision Française – le travail s'effectue au sein d'un Conseil de l'Audiovisuel qui comprend également des journalistes et, d'une façon générale, les spécialistes concernés par les thèmes à traiter.

Dans chaque cas se pose au moment du choix du thème de campagne, le problème de l'efficacité que l'on peut espérer d'une action d'information dans le domaine. Ce point, qui constitue apparemment une évidence, n'est selon nous pas toujours explicitement présent à l'esprit des responsables de campagnes. Tout permet de croire en effet que certains thèmes sont plus que d'autres accessibles à une campagne d'information et l'expérience pratique des campagnes nous conduit à établir une sorte de hiérarchie des difficultés que présente leur réalisation; dans cette hiérarchie le thème "alcool et conduite" occupe un rang élevé, peut-être le plus élevé.

De même il est probable que le public auquel s'adressent les campagnes ne présente pas une réceptivité uniforme et constante mais que cette réceptivité varie en fonction des circonstances politiques, sociales, économiques et en fonction des thèmes traités. En conséquence et très schematiquement la rentabilité d'un certain montant budgétaire consacré à une campagne pourra varier considerablement sans que la "qualité" de la campagne soit à mettre directement en cause. Il y a là nous semble-t-il un point qui mérite réflexion en particulier lors que l'on tente de comparer les succés et les échecs des campagnes futures.

---

[1] 2, Avenue du Général, Malleret, Joinville, Arcueil 94110, France.

Dans le cas de l'alcool et de la conduite nous avons différé à plusieurs reprises de campagnes envisagées sur ce thème parce que nous estimions insuffisante la préparation psychologique de l'opinion publique ou que les études préparatoires ne nous semblaient pas apporter d'informations susceptibles de guider la stratégie de notre campagne. La decision de mener une action au début de 1974 s'est fondée sur: (a) un examen de la situation actuelle en France: législation, attitudes, opinions, comportements des conducteurs et (b) la possibilité de proposer une stratégie en fonction des études préparatoires.

SITUATION ACTUELLE EN FRANCE

Du point de vue législatif cette situation est caractérisée par le double taux légal d'alcoolémie fixé à 0.80g/^{00} et 1.20g/^{00}.

Bien que la loi remonte à juillet 1970 son application a été très progressive et on peut dire que pour la plupart des automobilistes français cette mesure est encore une innovation. Elle a été largement commentée dans la presse mais demeure mal comprise dans son contenu exact, son intéret pour la sécurité, son degré réel d'application par la police.

Du point de vue des comportements des conducteurs, deux enquètes sur routes menées en 1969 et 1970 ont indiqué qu'en moyenne 3% des conducteurs présentaient une alcoolémie supérieure à 0.80g/^{00}. Pour des raisons principalement administratives nous n'avons pas pu répéter ces enquêtes avant et après la campagne ce qui a malheureusement exclu la possibilité d'en apprécier l'efficacité. Nous pensons toutefois que la situation doit être assez comparable à celle de 1970 car les chiffres d'alcoolisation des conducteurs accidentés publiés par la police et la gendarmerie n'ont pratiquement pas évolué.

Le chiffre de 3% n'est bien entendu qu'une moyenne calculée sur l'ensemble des heures et des jours; à certaines heures de la soirée et de la nuit en fin de semaine la proportion des conducteurs dont l'alcoolémie est supérieure à 0.80g/^{00} dépasse 20%.

En ce qui concerne les opinions et attitudes du public nous résumerons brièvement les résultats des études qualitatives (entretiens et analyses de contenu) et quantitatives (sondages d'opinion).

La grande majorité des personnes intérrogées admet parfaitement qu'il existe une relation entre l'alcoolisme et les accidents de la route mais cette notion reste très vague et sur un plan de grande géneralité. L'existence d'une loi limitant l'alcoolemie au volant est également connue mais très peu de conducteurs (2% environ) sont capables de préciser le contenu de la loi et ses conséquences pour les comportements à adopter.

Les conducteurs évitent de s'impliquer personnellement dans le problème de l'éthylisme au volant; ils utilisent des mécanismes psychologiques, de défense dont le plus répandu consiste à s'attribuer des capacités particulières de contrôle personnel et intuitif (ce que nous avons résumé sous le terme d'auto-contrôle') qui leur permettent de concilier deux types de satisfactions: satisfactions liées à la conduite et satisfactions liées à la consommation d'alcool.

L'auto-contrôle apparait comme l'élément central du système de raisonnement des conducteurs avec comme fonction première de réduire et même d'annuler ce que l'on pourrait qualifier de dissonance cognitive au sens de la psychologie sociale résultant de deux notions antinomiques:

1. L'alcool est cause de nombreux accidents.
2. Je peux boire et conduire sans augmenter mes risques d'accident.

STRATÉGIE DE LA CAMPAGNE

Choix des Media

Pour des raison pratiques (accord entre la télévision française et la Délégation à la Sécurité Routière) le principal de ces media devait être la télévision où nous disposons pour les campagnes de creneaux de 45 secondes à 13h30 et 19h00 et de 3 minutes chaque dimanche à 13h45. Cette primauté de la télévision sur les autres media, en quelque sorte imposée dans la stratégie, nous parait avoir une importance considérable dans la réalisation de la campagne. Le prestige de la télévision comme instrument de persuasion est très grand et l'on en vient parfois à confondre la valeur d'une campagne et le montant de son budget télévision. Or rien ne permet d'affirmer que tous les thèmes peuvent se prèter au style particulier qu'impose ce media; nous avons pu constater au cours de la campagne alcool et conduite à quel point il est difficile de trouver dans le message télévisé une traduction pour les conclusions des études préparatoires sans leur faire subir d'excessives distorsions.

Secondairement: – la presse écrite quotidienne et périodique
– l'affichage routier

Choix de l'Axe de la Campagne

Plusieurs axes étaient possibles qui furent examinés successivement.

Campagne explicative, rationnelle, axée sur le taux légal. Ceci pouvait se justifier par le caractère de nouveauté de la loi et sa mauvaise connaissance dans le public. Il fut ainsi envisagé d'expliquer en détail les raisons de la loi et d'indiquer d'une façon simple et familière les quantités d'alcool dont l'absorption peut mettre un conducteur en situation illégale. Ce projet fut écarté, les experts ayant refusé de se prononcer sur ces quantités par crainte que certains conducteurs très sensibles aux effets de l'alcool puissent à tort se croire en sécurité dans la mesure où leur consommation d'alcool demeurerait inférieure à ces chiffres. Il y a là nous semble-t-il un problème très sérieux dans la mesure ou la fixation d'un seuil légal est un compromis optimal entre la sécurité et le souci d'un certain réalisme dans la possibilité d'appliquer la loi. Il est donc assez paradoxal et génant pour les responsables d'une campagne de ne pouvoir expliquer ce qui est légal et ce qui ne l'est pas. A titre de comparaison il serait bien difficile d'expliquer aux conducteurs comment respecter une limitation de vitesse si les véhicules n'étaient pas équipés de tachymètres.

Présentation des statistiques d'accidents en insistant sur le caractère dramatique des chiffres. Cette approche assez traditionnelle, fut écartée car elle ne paraissait pas apporter d'élément réellement informatif pour les conducteurs, le rôle de l'alcool dans les accidents étant en général bien reconnu. Elle présentait le risque de favoriser la 'fuite dans la théorisation' mécanisme de défense volontiers mis en oeuvre par les conducteurs qui dissertent sur les aspects généraux du problème en évitant de s'impliquer personnellement dans leur pratique quotidienne de la conduite.

Nous souhaitions par ailleurs éviter d'utiliser massivement la peur en présentant par exemple des scènes très réalistes d'accidents. De tels messages ont été déjà largement utilisés par des organismes de lutte contre l'alcoolisme et nous voulions donner à la campagne un ton différent qui permette au public d'y reconnaître les messages de spécialistes de la sécurité routière traitant d'un problème de conduite.

L'axe finalement retenu tente de combattre la notion décrite comme 'autocontrole'. Les messages sont conçus autour de l'idée suivante "l'alcool augmente *vos propres* risques d'accident et précisément lorsque vous êtes sous influence d'alcool vous ne pouvez plus le savoir".

Ceci est diversement explicite dans les messages qui mettent en scène des situations de la vie courante où un conducteur peut être amené à s'alcooliser sous la pression sociale tout en sachant que ceci comporte un risque accru d'accident. On a cherché à souligner le paradoxe de la coexistence chez un même individu d'un raisonnement conforme à la sécurité et d'un comportement dangereux.

CONCLUSION

Depuis quelques années on assiste à la généralisation de contrôles de l'efficacité des campagnes et il y a là, nous semble-t-il, un apport essentiel à la progression de nos connaissances dans ce domaine. Encore une fois nous regrettons de n'avoir pu réaliser en 1974 de tels contrôles pour l'alcool et la conduite comme nous l'avons fait dans d'autres cas, par exemple, le port des ceintures de sécurité.

Mais le souci de contrôle ne doit pas faire passer dans l'ombre la nécéssité de préciser les hypothèses qui vont guider la stratégie.

Il y a, semble-t-il, chez les spécialistes de l'information une tendance plus grande à investir des efforts dans la qualité de la planification des media et de la réalisation des messages que dans la mise au point de schémas explicatifs justifiant le choix de la campagne comme moyen d'action. A la question "quelle campagne allons nous entreprendre", il faudrait peut-être substituer la question – "Dans notre connaissance de tel aspect de la sécurité routière quels sont les éléments qui justifient la planification d'une campagne"?

One Model for the Evaluation of ASAP Rehabilitation Efforts

James L. Nichols[1] and Raymond E. Reis

HISTORY OF ASAP

In 1966 a report was submitted to the Congress of the United States by the Secretary of Transportation (21). This report identified alcohol as the largest single factor contributing to fatal crashes in the United States. It indicated that 50 per cent of all highway fatalities were alcohol-related and suggested that alcoholics and problem drinkers contributed to a large proportion of such fatalities.

In June of 1970, the U.S. Department of Transportation began the initial funding of what would become 35 demonstration alcohol countermeasure projects known as the Alcohol Safety Action Projects (ASAPs). The ultimate goal of each ASAP was to reduce alcohol-related, fatal, injury and property damage crashes by reducing the number of persons driving vehicles while intoxicated (DWI).

One of the objectives of this federal program was to coordinate the activities of existing agencies at State and local levels such that each demonstration project would function as a comprehensive drinking-driver control system. This system would involve several subsystem components, such as the legislature, police, courts, media, and alcohol treatment agencies. One of the major failures of such control systems in the past had been their lack of coordination among the various agencies involved (9). Individual agencies often failed to perceive their activities in relation to other agencies or in relation to a shared set of total system objectives. For example, few courts possessed adequate systematic procedures to allow for the diagnosis and referral of problem drinkers to local treatment resources. Similarly, few treatment centers had programs suitable for court-referred problem drinkers. Thus, the two agencies most closely related to the potential change of problem drinking behavior often operated in relative isolation of each other.

In addition to the integration of existing community resources, innovative procedures were developed to deal with drinking-drivers. They included pre-sentence investigations designed to identify problem drinkers, and short-term treatment alternatives to the sanctioning procedure.

The present study addresses itself to the ASAP rehabilitation subsystem. The goal of this subsystem, as originally set forth, is to modify the behavior of persons convicted of DWI in a manner that will reduce the probability of subsequent DWI behavior. Other goals and objectives are also present among the persons working within this area. Some of these include: (a) improving the life status of problem drinkers by reducing problem-related drinking behavior; (b) minimizing unwanted side-effects of large scale enforcement and adjudication effects upon persons who may be leading a marginal existence; (c) lending organization to the problem drinker diagnosis, referral, and treatment community; (d) improving the quality of treatment program evaluation and (e) communicating the results of such program evaluation efforts to the outside world, by contributing to the quality and body of alcohol rehabilitation literature.

---

[1] Office of Driver & Pedestrian Programs, National Highway Traffic Safety Administration, Washington, D.C., U.S.A.

There have been many obstacles in the way of reaching any one of these goals. In some cases, organization and planning at various levels of the program have been lacking. In others, there has been a reluctance to systematically refer persons from the courts to the treatment community. In still others, a reluctance to collect necessary data was apparent. In most cases persons involved at the project and community level have refused to implement the control group design procedures which are necessary for an adequate evaluation of program effectiveness. Efforts in this area continue to improve, however, and the present study is merely a step in the evolution of that process.

A BACKGROUND OF RELATED REHABILITATION EFFORTS

Before continuing further into a description of the evaluation approach taken by the National Highway Traffic Safety Administration (NHTSA), it would be well to review the present status of literature in this area. For reasons apparent in the methods section of this paper, such a review will concentrate on the effectiveness of rehabilitation programs in modifying the re-arrest frequency of persons exposed to them. Figure 1 describes two general areas of relevant background literature including the driver training area and the alcohol rehabilitation area.

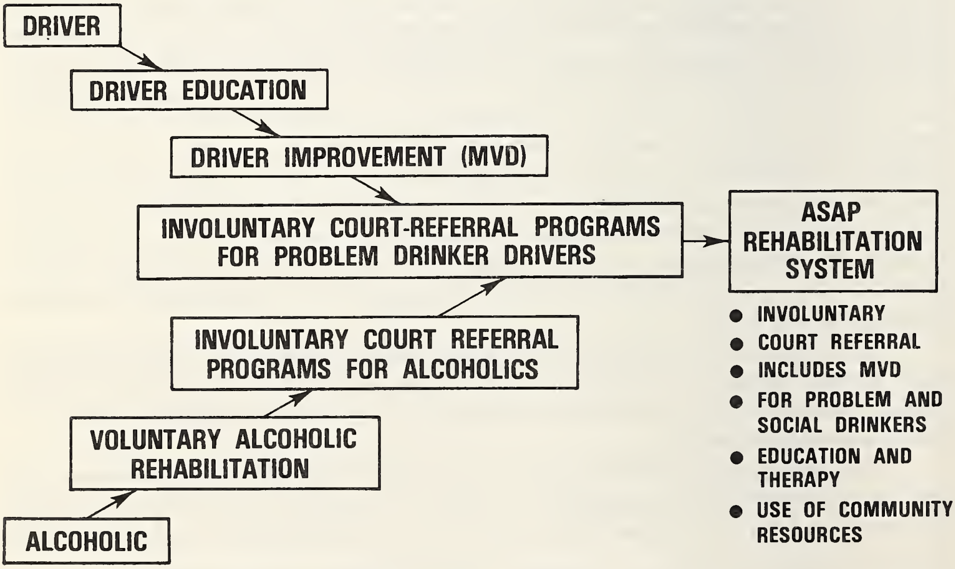

DRIVER
DRIVER EDUCATION
DRIVER IMPROVEMENT (MVD)
INVOLUNTARY COURT-REFERRAL PROGRAMS FOR PROBLEM DRINKER DRIVERS
ASAP REHABILITATION SYSTEM
● INVOLUNTARY
● COURT REFERRAL
● INCLUDES MVD
● FOR PROBLEM AND SOCIAL DRINKERS
● EDUCATION AND THERAPY
● USE OF COMMUNITY RESOURCES
INVOLUNTARY COURT REFERRAL PROGRAMS FOR ALCOHOLICS
VOLUNTARY ALCOHOLIC REHABILITATION
ALCOHOLIC

Figure 1 *The History Behind ASAP Rehabilitation Efforts*

Efforts in the more general driver improvement area have been less than spectacular. In a 1968 review of the major controlled studies of driver improvement (11) it was indicated that while such programs could be expected to reduce subsequent violations among drivers exposed to them, their ability to reduce crashes among such drivers was not apparent. A more recent review (7) suggested that even if such programs were 100 per cent effective in modifying the behaviors of known problem drivers, the resultant impact on total fatal crashes would be quite small.

In the general alcohol rehabilitation area, a similar situation exists. A recent review of the literature in this area (16) evaluated the relative effectiveness of various treatment alternatives which were potentially available to the ASAP system. The study concluded that due to a lack of substantive research findings, no single approach could be recommended, without reservation, as being superior in effectiveness. In fact, because of a lack of controlled studies, it was difficult to determine if *any* of the particular modalities had significant behavioral effects on the persons exposed to them. Of the modalities reviewed, however, fairly long term combinations of chemotherapy and group psychotherapy appeared to hold the most promise.

Two other studies are worth noting with regard to the evaluation of treatment modalities within the general alcohol rehabilitation area. The first study conducted in 1942 (23) concluded that, up to that time, there was no evidence that individual psychotherapy programs were of any value in treating alcoholism. The second study, conducted 25 years later (8) came to the same conclusion. While these studies did not prove that psychotherapy was completely ineffective in the treatment of alcoholism, they did indicate that the implementation and/or evaluation of such programs had never been systematic or controlled enough to enable a determination of which kinds of clients would be expected to benefit from such programs and which would not.

Moving into the area of involuntary referral programs, there has been some recent evidence in the literature that, contrary to earlier beliefs, such programs can be successful in getting persons into treatment programs; keeping them in such programs; and motivating them to respond to treatment efforts (1, 14, 17). While there are also suggestions in the literature that the drinking behaviors of a substantial number of such persons could be changed, evidence here was much less convincing and even less so with regard to reducing subsequent alcohol-related arrests.

With regard to treatment programs for drinker-drivers, purely educational efforts were first documented with a program in Phoenix, Arizona. Evaluations of this program (4, 22) have suggested that it may be effective in reducing violations among those exposed to it (as compared with a control group) but no evidence concerning the program's crash reduction potential has been provided to date. In studies of more comprehensive drinker-driver treatment programs, a Colorado study (2) suggested that a treatment sanctioning alternative examined in that city resulted in no fewer subsequent alcohol-related driving offenses among convicted DWIs than did penal oriented sanctions. However, a long term evaluation (12) of two recent California prototype programs (15, 16, 17) has suggested that comprehensive treatment programs may be effective in reducing subsequent alcohol-related violations and crashes among persons exposed to them. A more extensive review of research in this area can be found in a recent report on ASAP rehabilitation activities (22).

ASAP REHABILITATION EFFORTS

Development

During the development stages of the ASAP program, it was decided that ASAP funds would not be allocated for costly, long term therapy or medical care. Considering the number of persons who had to be processed from the courts and the amount of funding which was available, it was apparent that such programs could not be fully supported. As an alternative, the ASAPs were to provide a referral mechanism between the courts and the community treatment agencies, which were capable of supporting longer term treatment. In addition to soliciting the aid of the National Institute of Alcoholism and Alcohol Abuse (NIAAA) in supporting such community programs, the NHTSA endorsed a program of short-term, group-oriented rehabilitation modalities to aid individuals in the transition between the courts and the community resources. This transitional ASAP rehabilitation program, as envisioned, can be seen in Figure 2.

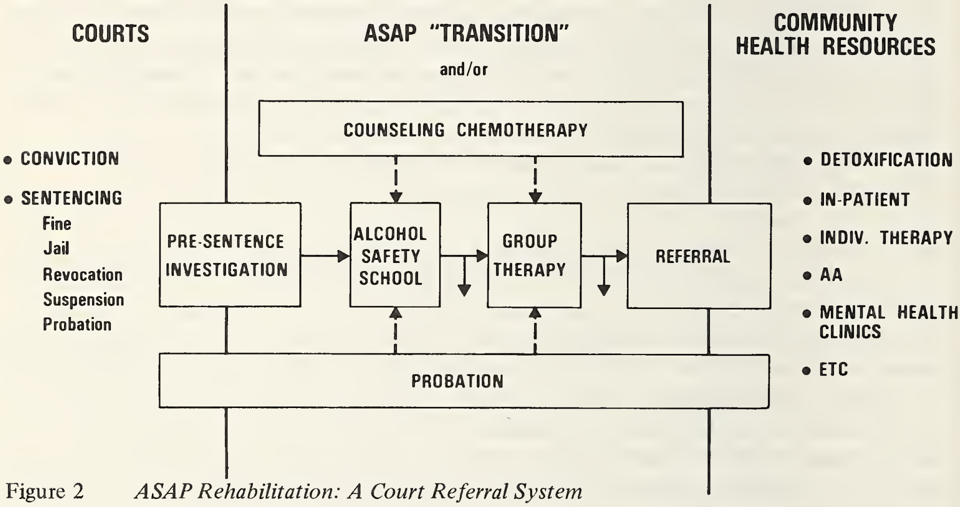


Figure 2 *ASAP Rehabilitation: A Court Referral System*

Unfortunately, the greater proportion of individuals who entered the ASAP treatment system were never exposed to long term treatment programs. For such persons, the short term educational (and to a lesser extent group therapy) modalities provided the only exposure to rehabilitation efforts. The present study specifically addresses the effectiveness of such short term efforts, especially with regard to the alcohol safety schools.

Program Level Evaluation

Earlier NHTSA efforts to evaluate ASAP rehabilitation programs were less than satisfactory (22). On the program level, a format was developed to enable reporting recidivism rates (re-arrests for an alcohol-related offense) for a variety of treatment modalities. This reporting format will subsequently be referred to as *Table 15*.

Little was gleaned from this effort in the first two years of its use. The primary reasons for this lack of results included: (a) inadequate definition of the term recidivism; (b) failure to segregate data for problem and non-problem drinkers; (c) inadequate specification of modality characteristics; (d) a lack of adequate control or comparison groups; and (e) differences in the quality of data collection and recording procedures at the various projects. As a result, it was possible only to derive an approximate 12 month recidivism rate from these data. This estimate indicated that about 6 per cent of those persons entering the ASAP program could be expected to be re-arrested for an alcohol-related offense within the next 12 month period. While there were indications that this rate may have been lower for persons exposed to chemotherapy (disulfiram) programs, sufficient control was not present to make such a claim (Table I).

TABLE I *Recidivism Rates for Basic Treatment Modalities*

	Alcohol Safety School	Indiv. and Group Therapy	Chemo-Therapy	Total Rehab.
Total Entering by 2nd Quarter 1972	6,107	1,066	771	12,834
No. Recidivating Within 4 Quarters (12 Months)	336	61	29	815
Approximate 12 Month Recidivism Rate	5.5%	5.7%	3.8%	6.4%

Project Level Evaluation

In order to evaluate the effectiveness of ASAP rehabilitation efforts at a project level, guidelines were set up for an *analytic study* to be conducted by each project in this area. This procedure will subsequently be referred to as the analytic study #6 procedure. Although all modalities were of potential interest to evaluators, nearly all of the first year's analytic study effort was directed to an evaluation of the alcohol safety schools. This was probably justified, since approximately 72 per cent of the treatment effort for 1972 was educationally oriented. As Table II indicates, these studies included several criterion measures of effectiveness. These measures included attitude and knowledge level change; violations; and (in one study) crash reductions.

TABLE II *Results of Analytical Studies of Effectiveness of Alcohol Safety Schools*

	Measures of Effectiveness			
	Knowledge Increase	Attitude Change	Violation Decrease	Crash Decrease
Number of Studies Reporting	13	9	10*	1
% Reporting Positive Results	100%	56%	60%	0%

*only 2 were well controlled studies.

The evidence with regard to increases in *knowledge* level as a result of exposure to the various schools was quite consistent. In the area of positive *attitude* changes, the data were less convincing and in the area of *crash*-reductions, evidence for such an effect was non-existent. At first glance, it appeared that many schools were being effective in reducing subsequent alcohol-related *violations*.

As Table II points out, six of the ten studies which examined arrest recidivism reported results favoring the educational program. On close inspection, however, only two studies used randomly assigned control groups. Of these studies, one showed significant favorable results for the school group and the other failed to find any significant differences between the school and control groups.

Three additional studies included control and experimental groups which were matched on at least one variable related to recidivism. Of these three studies only one reported significant results favoring the education group. In general, as the amount of control decreased, the number of studies reporting favorable results increased. This relationship has been noted with other programs (19).

As a result of the lack of adequate evaluation procedures in 1972, guidelines and format for both the program level (*Table 15*) and project level (analytic study #6) evaluation efforts were revised extensively. The present study reflects such revisions as well as an initial *program* level analysis conducted on the educational modalities. (A review of the most recent analytic study findings is also proceeding at this time and the results will be reported at a later date.)

VARIATIONS AMONG EDUCATIONAL PROGRAMS

The importance of selecting the appropriate treatment modalities for individuals with particular personality characteristics and drinking patterns has often been suggested. However, it has already been pointed out that the type of offender who benefits the most (or least) from various modality approaches is not known. This is also the case among the several educational approaches included within the general rubric of alcohol safety schools.

The particular organization and orientation of alcohol safety schools, and to a lesser extent group therapies, varies widely within and between the 27 ASAP sites included in this study. Differences in alcohol safety schools are largely a function of the type of drinker for whom the curriculum was originally designed. Schools designed for social drinkers tended to be didactic and oriented toward information transmission. Schools for problem drinkers tended to have more discussion and more social, emotional, and behavioral counseling than their social drinker counterparts. When ASAPs became operational, however, many courts referred offenders to schools regardless of the drinker type they were designed for. Occasionally, such referrals were made necessary by overloads in a particular modality.

PURPOSE OF THE STUDY

The purpose of the present study was twofold. First, it was intended to develop a model for program level evaluation using reported arrest recidivism rates. Second, it was intended to determine the effectiveness of various school types in the reduction of arrest recidivism. However, since few projects reported recidivism data for persons assigned to no-treatment control groups, the alternative remaining was to compare the effectiveness of different school types. In this study the structural characteristics of ASAP education and group therapy modalities as they evolved in different communities, were first identified and described. The alcohol safety schools were then grouped into categories or types which were more homogeneous in terms of such organizational characteristics. Finally, differences in recidivism rates between drinker types and school types were examined.

METHODS

The tasks conducted in the present investigation and described in this section are as follows:

(a) Selection of a suitable *criterion measure* for evaluating treatment program effectiveness.
(b) Selection and modification of a criterion *data collection procedure.*
(c) Selection of a suitable method for *calculating recidivism rates.*
(d) Selection of a formula for *transforming recidivism data* into a form appropriate for data analysis.
(e) Specification of the *differences between* various *drinker (client) types.*
(f) Development of a device for specifying the characteristics of various *modality types.*
(g) Selection of a procedure for *discriminating between* various *modality (school) types.*
(h) Conducting appropriate statistical *analyses of recidivism* rates between:
  i) *drinker* types;
  ii) *school* types; and
  iii) interactions of drinker and school types.

Selection of a Criterion Measure

In order to be considered effective, the education and group therapy treatment modalities would be expected to decrease the frequency of driving while intoxicated for persons exposed to them. Direct measures of such DWI behavior, however, would require constant surveillance of these individuals. For a variety of reasons, such surveillance was not considered feasible for the present study.

A number of indirect (or proxy) measures of driving behavior have been suggested. For example, fatal and injury crashes would be a good proxy measure since their reduction is the ultimate goal of ASAP. In addition, each occurrence of a fatal or serious injury crash is visible to authorities and thus likely to become a matter of public record. However, a major disadvantage of the use of crashes (particularly fatal crashes) is their rarity of occurrence. Not only are fatal crashes relatively rare events (in a statistical sense), alcohol-related fatal crashes are even twice as infrequent[2] and those fatal crashes involving a person with a previous conviction for DWI are approximately 25 times as rare[3]. From the target group side of the picture, it has been estimated that for every convicted DWI who becomes involved in a subsequent fatal crash approximately 600 do not[4]. Thus, it is apparent that unless data were collected on a massive number of treated DWI clients, it would be difficult to accumulate a sufficient number of fatal crash observations to conduct statistical tests.

---

[2] It is estimated that approximately 1/2 of all fatalities result from an alcohol related crash.

[3] Data from an NHTSA supported study (5) suggested that only about 4 per cent of the fatally injured drivers sampled had a previous DWI conviction.

[4] Estimates derived from a present in-house NHTSA effort to develop models for target group involvement in fatal crashes using a variety of data sources.

Another proxy measure of effectiveness is arrest recidivism. In the present context, recidivism is defined as a re-arrest for an alcohol-related offense following entry into an assigned treatment modality. From a frequency point of view, this measure is certainly less desirable than is the direct surveillance of DWI behavior since it has been estimated that the probability of an intoxicated driver actually being arrested for DWI (much less convicted) is between 1/1000 and 1/2000 (3). On the other hand, such re-arrests are much more frequent among convicted DWIs than are subsequent fatal crashes. In fact they are probably more than 36 times as frequent[5]. *Arrest recidivism was the criterion measure chosen for the present study.*

Another potential measure of treatment effectiveness is the subjective report of life changes. Here the assumption is made that reports of decreasing alcohol-related problems (of which a DWI conviction is only a small part) signify a decrease in problem drinking behavior (including DWI). The obvious advantage with such a criterion is that it would measure changes in a criterion which is characteristic of 100 per cent of the problem drinker DWI population since, by definition, all of them have drinking-related problems. This can be compared to the approximate 12 per cent of problem drinker DWIs who are re-arrested for an alcohol-related offense in a subsequent 12 month period. Furthermore, with life change criteria, an assessment can be made of the social benefits outside the driving sphere which may be derived from effective treatment programs. Life change measures, however, were not available for the present study.

DATA SOURCES

The data sources for this study were 27 Alcohol Safety Action Projects (ASAPs) which were in operation during calendar year 1973.

Criterion Data Collection Procedure

The revised standard reporting form (Evaluation *Table 15*) and the instructions for its use appear in Appendix A. As in prior years, the 27 ASAP projects included in this study used *Table 15* to report the number of persons *entering* each treatment modality for each quarter the project was in operation. They also reported the number of each quarter's entries which were *re-arrested* (recidivated) in subsequent quarters.

The primary changes from the 1972 to the 1973 reporting procedure included:

1. Recidivism was formally defined as a re-arrest for an alcohol-related driving offense following entry into a treatment modality.
2. A separate recidivism table was completed for diagnosed problem drinkers; non-problem drinkers; and unidentified drinkers.
3. For the first year following entry into treatment, recidivism was reported in *one* rather than *two* quarter intervals.

The last reporting quarter for the data in this study ended December 31, 1973. For the majority of ASAP sites which first began operation in quarter one of 1972, referrals had a maximum of eight quarters of exposure time to re-arrest.

---

[5] Figuring approximately 6 per cent of DWIs are re-arrested for DWI within the following 12 months this would result in approximately 36 recidivist for every 600 DWIs as compared with 1 fatality for every 600 DWIs. (This is probably a conservative estimate.)

Calculation of Recidivism Rates

There are a variety of ways to calculate recidivism rates, all of which include some advantages and some disadvantages. In the present study it was decided to use a method whereby recidivism rates would be estimated for each quarter of exposure following entry into a treatment modality. All treatment entries were used regardless of whether or not they completed the program; dropped out of their own accord; or dropped out because of a re-arrest for DWI. Although *Table 15* called for the separation of these groups, in reality it proved to be a difficult task. The recidivism rate estimate for each quarter of exposure was derived by dividing the total number of persons re-arrested during that quarter of exposure by the total number of persons exposed for that length of time.

Example:

$$\text{Quarterly Recidivism Rate} = \frac{\text{Number re-arrested in that quarter following entry}}{\text{Number exposed for that many quarters}}$$

Figure 3 illustrates this procedure. Individuals entered treatment at different times throughout the year. Entries in later quarters do not have as long an exposure period as those entering in earlier quarters. Thus, later quarter treatment entries can only be used in the estimation of shorter term (e.g., 1st quarter) recidivism rates and the rate estimates for various exposure quarters are based on a different sample sizes.

Figure 3

After calculating quarterly recidivism rates in the manner described these quarterly rates were then summed to provide cumulative quarterly rates.

Example:

$$\text{Cumulative two-quarter recidivism rate} = \text{Rate for first quarter of exposure} + \text{rate for second quarter of exposure}$$

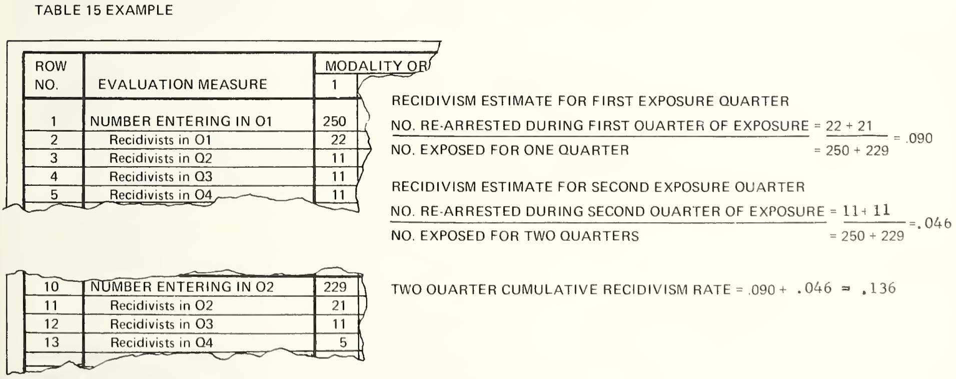


TABLE 15 EXAMPLE

ROW NO.	EVALUATION MEASURE	MODALITY OR 1
1	NUMBER ENTERING IN Q1	250
2	Recidivists in Q1	22
3	Recidivists in Q2	11
4	Recidivists in Q3	11
5	Recidivists in Q4	11

10	NUMBER ENTERING IN Q2	229
11	Recidivists in Q2	21
12	Recidivists in Q3	11
13	Recidivists in Q4	5

RECIDIVISM ESTIMATE FOR FIRST EXPOSURE QUARTER

$$\frac{\text{NO. RE-ARRESTED DURING FIRST QUARTER OF EXPOSURE}}{\text{NO. EXPOSED FOR ONE QUARTER}} = \frac{22 + 21}{250 + 229} = .090$$

RECIDIVISM ESTIMATE FOR SECOND EXPOSURE QUARTER

$$\frac{\text{NO. RE-ARRESTED DURING SECOND QUARTER OF EXPOSURE}}{\text{NO. EXPOSED FOR TWO QUARTERS}} = \frac{11 + 11}{250 + 229} = .046$$

TWO QUARTER CUMULATIVE RECIDIVISM RATE = .090 + .046 = .136

Figure 3 *Procedure for Estimating Quarterly and Cumulative Recidivism Rates.*

Each quarterly rate represents the best estimate of the performance of all individuals at that point in time following entry into treatment. Shorter term exposure rates (e.g., Q_1 or Q_2) should be more stable than longer term estimates (e.g., Q_4 or Q_6) since they are based on a larger sample of persons exposed for that period of time.

Transformation of Recidivism Data

For the purpose of statistical analyses, cumulative recidivism rates (CR) were transformed by the formula:

$$\mathrm{CRT} = 2 \arcsin \sqrt{\mathrm{CR}}$$

Thus cumulative recidivism rates (CR) were transformed into arc sin cumulative recidivism rates (CRT). The arc sin transformation was selected since it: (a) reduces heterogeneity of variance between comparison groups and (b) provides for a more normal distribution of recidivism rates.

Sources of Interproject Variance in Reporting Recidivism Data

Several sources of interproject variance in reporting procedure exist. Some of these include: (a) the sophistication of Department of Motor Vehicle (DMV) record systems; (b) the amount of transience in the various project area populations; (c) differences in laws and sanctions; particularly with regard to license suspension; and (d) differences in arrest intensity. While all of these factors (and others) could affect the quality of the data collected, one of the more important variables, arrest intensity, was examined and found not to be significantly related to recidivism rates. Most of the factors are difficult to measure at the program level and were not accounted for in this study.

There were other factors, of course, capable of contaminating the data. For example, with regard to classification by modality type, a participant in any modality can volunteer at any time for additional treatment. It is virtually impossible for the project evaluator to have a knowledge of all such events. With regard to court-referred rehabilitation, however, some of such variability was removed by including for recidivism analysis *only* those clients referred *solely* to the alcohol safety schools. This would have been more difficult to do with any other modality including the group therapies and is one reason why recidivism analyses were conducted only on alcohol safety schools in this study.

Finally, most participants in an alcohol safety school attended under some form of judicial incentive or coercion. It is difficult to scale such incentives and/or restraints on a meaningful continuum of intensity or even to develop a taxonomy of conditions of participation which is consistent across projects. Thus, such conditions as well as others, (like prior arrests) were not considered in this program level analysis of recidivism data.

Diagnosis of Drinker Types

As indicated previously, the instructions contained in *Table 15* require the reporting of separate recidivism data for each of three drinker types. The ASAP diagnostic procedure included guideline criteria for identifying a problem drinker. These criteria included:

1. Diagnosis as an alcoholic by a competent medical or treatment facility, *or*
2. Self admission of alcoholism or problem drinking, *or*
3. Two or more of the following:
    a) A BAC of .15 per cent or more at the time of arrest,
    b) A record of one or more prior alcohol-related arrests,
    c) A record of previous alcohol-related contacts with medical, social, or community agencies,
    d) Reports of marital, employment, or social problems related to alcohol,
    e) Diagnosis of problem drinker on the basis of an approved structured written diagnostic interview instrument.

Individuals who were diagnosed but were not classified as problem drinkers were considered non-problem drinkers. A third category of unidentified drinkers was available to indicate people for whom no diagnosis was made or for whom there was insufficient information to make a classification. In practice, however, several ASAPs used the unidentified category for people with drinking problems of intermediate severity. For this reason, recidivism data for unidentified drinkers were not used in this study.

Specifying the Characteristics of Modality Types

Specification of the characteristics of ASAP educational and group therapy modalities was accomplished using the questionnaire form shown in Appendix B. This device was designed to measure the observable, structural characteristics of these modalities such as: (a) the proportion of time spent in didactic approaches; (b) the percentage of time spent in discussion among participants themselves; (c) number of clients per session. The information was collected from a series of on-site interviews with one or more persons familiar with the modality. In some cases, several instructors or therapists completed a questionnaire about a particular modality. In these cases, the responses were averaged. Most often, however, a single expert such as the ASAP rehabilitation coordinator completed the forms.

The qualifications and talents of the modality leader or instructor are likely to be the most important variables relating to modality effectiveness. Unfortunately, the specific characteristics which relate to effectiveness for various client types have not yet been accurately specified and, for a variety of reasons, would not be easy to assess. Describing a modality in terms of leader characteristics is further complicated by the relatively high turnover rate of instructors and therapists. For these reasons, leader qualifications were not represented in the modality profiles developed.

The final profile variables which did result from this effort included the following:

1. Information transmission (proportion of time spent in this activity).
2. Participant-leader interaction (proportion of time spent in this activity).
3. Participant-participant interaction (proportion of time spent in this activity).
4. Total client exposure time (number of minutes or hours exposed).
5. Average session size (number of clients per session).

Complete profile variables were obtained for 76 rehabilitation modalities at the 27 ASAP sites. For labeling purposes, these modalities were divided a priori into 44 alcohol safety schools and 32 group therapies. The criteria for labeling the modalities were as follows:

1. If a modality was labeled as an alcohol safety school (or educational program) by the project, it remained as such.

2. If a modality was labeled as a group therapy by the project and its profile did not indicate that 60 per cent or more of its total exposure time was spent in information transmission activities, it remained as such. Otherwise it was relabeled as an alcohol safety school.

Discriminating Between Various Modality Types

Principal components analysis. In order to derive some meaningful dimension(s) on which the various modality types could be separated or clustered, the five profile variable scores for each of the 76 rehabilitation modalities were subjected to a principal components factor analysis. For each *dimension* or *factor root* derived which accounted for an acceptable proportion of the variance in the profile variable scores, *factor scores* were obtained for each of the 76 modalities. A factor score for a particular modality was calculated by multiplying each standardized variable score for that modality (plus a constant of five) by its respective standardized factor weight, then summing all five weighted profile variables.

Example: $(V_1 + 5) W_1 + (V_2 + 5)W_2 \ldots + (V_5 + 5)W_5$

where Vi = standardized profile variable score
Wi = standardized profile variable factor weight
$i = 1,5$

A separate factor score was calculated for each treatment modality on each significant dimension derived by the factor analysis. This factor score can be interpreted as the position of that modality on the dimension from which the factor weights were derived. The meaning of such a dimension, of course, is inferred upon inspection of the factor loadings for the variables in the profile.

Hierarchical cluster analysis. Once factor scores were obtained for the alcohol safety schools, it was desirable to identify natural clusters, or groups, of schools which had similar scores on each root (or dimension). It was expected that school types (or groups) thus derived would provide a basis for examining the effects of different rehabilitation approaches in altering the recidivism patterns of different drinker types. (In the present study only the schools were grouped in this manner and examined with regard to statistical analyses of recidivism rates.)

A hierarchical clustering algorithm developed by Ward (26) was selected to perform this clustering task. An explanation of the nature of this procedure can be found in two brief references (23, 25). Basically, however, the procedure begins by grouping schools with similar factor scores in a progressive basis which minimizes the error within any grouping. As the schools are combined into fewer, but larger groups, the within-group error increases[6]. The procedure ends when all schools have been classified into one of two groups. The researcher must decide, on the basis of within-group error, at which level of the heirarchy to select his groups. The decision rule used in selecting the school types in this study was to use the level with the fewest number of clusters where the next merging of schools would result in a substantial increase in error. The computer programs for both the principal components analysis and the cluster analysis can be found in Veldman (23).

---

[6] In reality the procedure works from a symmetric, school by school, matrix in which each matrix element is the squared difference between its associated row and column factor scores, divided by the number of schools represented in each difference (e.g., in the first case two).

Analysis of Recidivism Rates for Drinker Types

For each drinker type (*i.e.*, problem and non-problem drinkers) cumulative quarterly recidivism rates were calculated and transformed using the arc sin transformation. Differences between these transformed quarterly profiles were then tested using a profile analysis (27). In this test a multivariate analysis of variance is performed on (p-1) successive differences in a profile of p variables (in this case p=5 quarterly differences). The primary hypothesis tested by this procedure, which is of interest to this study is that the profiles are parallel[7]. This test is analagous to a univariate test of interaction. In the present situation this test addresses the question of whether the shape of the cumulative recidivism curves is different for each drinker type.

Four additional one-way analyses of variance were performed on the cumulative rates at each quarter interval of exposure. These analyses were included for two reasons:

1. Since the profiles were cumulative in nature the profile analysis of between group differences (which would have examined cumulative scores) is not as interpretable as univariate test of differences at each quarter.
2. Recidivism rates at different quarter intervals were based on different sample sizes (*i.e.*, shorter exposure rates were based on larger sample sizes than longer exposure rates). Only schools which had complete data for all exposure periods could be included in the profile analysis. Univariate tests, however, could be performed on the total number of schools which had data for a particular quarter of exposure regardless of whether they had complete data for all quarters. Thus, analyses could be conducted on larger, more stable samples, using the univariate test.

All analyses of variance were performed according to the general linear model with a step-down solution through an a priori ordering of effects (13). The alpha level was set at .05 for all analyses. The strength of the relationship between recidivism rates and taxonomic factors was estimated by the formula:

$$\text{Eta squared: } \frac{\text{SS Hypothesis} - \text{SS Error}}{\text{SS Total} \quad + \text{SS Error}}$$

Eta squared can be interpreted as the percentage of variance in recidivism rates that can be attributed to the independent variable.

Analysis of Recidivism Rates for School Types

For each drinker type, a profile analysis was performed on the school types determined by the clustering analysis. In addition, five two-way analyses of variance, (*i.e.*, school type by drinker type) were performed on the cumulative recidivism rate at each quarter in the profile. Separate statistical analyses were performed on school types for each factor root[8]. The school type effect was always tested first in the general linear model. Every alcohol safety school was considered as a separate school for each drinker type attending it.

---

[7] Two other tests are also made using this procedure, one is a test of no slope and the other is a test of between group differences in the sum of the p variables. However, since the data used in the profiles were cumulative in nature, these tests were not considered relevant.

[8] While school types were derived on the second root and recidivism analyses were conducted on these root 2 school types, the results of such tests are not reported in this paper due to space constraints and due to problems in interpreting the meaning of root 2.

RESULTS

Discriminating Between Various Modality Types

Principal components factor analyses. The results of the principal components analysis conducted on the five profile scores for each of the 76 treatment modalities are shown in Table III. Two principal components or factor roots were identified which accounted for 49.9 per cent and 25.6 per cent of variance respectively. These factor roots can be pictured as orthogonal dimensions on which the 76 modalities can be arrayed.

Figure 4 illustrates these two roots or dimensions graphically and suggests the characteristics of each, as derived from the factor weights shown in Table III.

TABLE III *Principal Components Factor Loadings and Standardized Factor Weights*

	Root 1		Root 2	
Variables	Loadings	Weights	Loadings	Weights
Information Transmission	–.8862	–.3546	.1070	.0836
Participant-Leader Interaction	.2483	.0993	.9231	.7208
Participant-Participant Interaction	.7788	.3116	–.5619	–.4388
Total Exposure Time	.7047	.2820	.2880	.2249
Average Session Size	–.7410	–.2965	–.1354	–.1057
Percent of Trace	49.98		25.61	

As can be seen, the first factor or dimension had high negative loadings for the information transmission and session size variables and high positive loadings for the participant-participant interaction and exposure time variables. Thus high scores for information transmission (*i.e.*, much session time devoted to this activity) or for session size (*i.e.*, large number of participants per class) would tend to place a modality on the left or negative side of this dimension as illustrated in Figure 4.

On the other hand, high scores for exposure time (*i.e.*, program required much time to complete) or for participant-participant interaction (*i.e.*, much time spent with clients interacting with each other as in encounter groups) would tend to place a

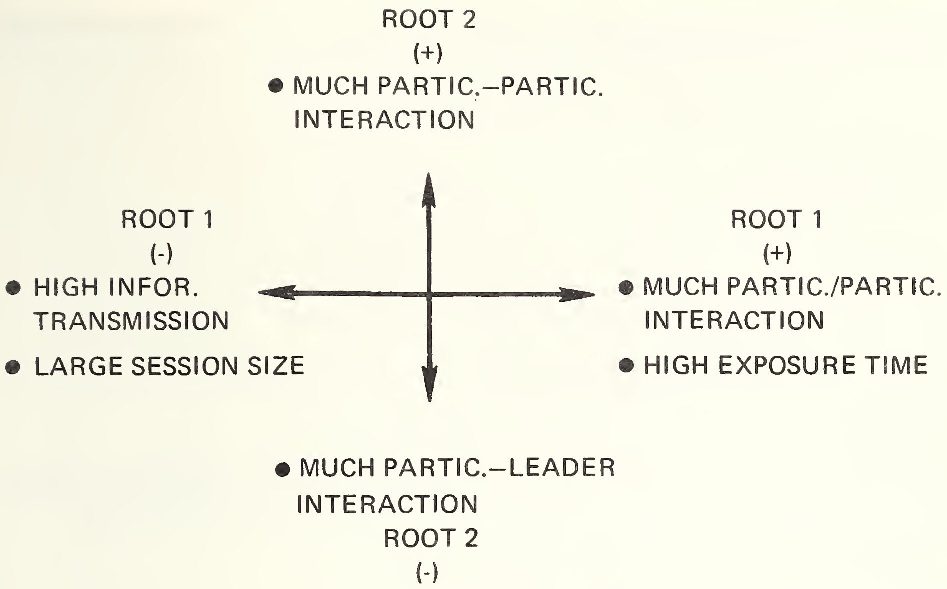

ROOT 2
(+)
● MUCH PARTIC.–PARTIC. INTERACTION
ROOT 1
(-)
● HIGH INFOR. TRANSMISSION
● LARGE SESSION SIZE
ROOT 1
(+)
● MUCH PARTIC./PARTIC. INTERACTION
● HIGH EXPOSURE TIME
● MUCH PARTIC.–LEADER INTERACTION
ROOT 2
(-)

Figure 4 *Characteristics of Dimensions Derived from Factor Analysis*

modality on the right or positive side of the first dimension. A high score for participant-leader interaction did not weigh heavily in placing a modality on either side of the dimension.

Any rehabilitation modality with a high *negative factor score* on root 1 would be placed on the negative side of this dimension and would be characterized by: (a) a large number of participants; (b) much time allocated to didactic educational activities (rather than counseling activities); (c) relatively short time intervals; and (d) little interaction among participants themselves. A modality with these characteristics would likely be a two session, lecture oriented alcohol safety school.

A modality with a high *positive factor score* on root 1 would be placed on the right side of that dimension and would involve: (a) relatively long exposure time or many sessions; (b) a small number of participants at each session; (c) little time spent in didactic educational activities; and (d) much time spent with participants interacting with each other. Modalities with such traits would be more therapeutic oriented.

Thus, the first root can be conceptualized as a dimension representing the educational vs therapy approaches taken by the various modalities. Since this root accounted for nearly twice as much variance as the second root and since the second root is somewhat more difficult to interpret, the remainder of this paper will be limited to the analysis of modalities situated on this first dimension.

The factor scores for each modality are listed in Appendix C. The first two letters of the modality code indicate the state in which the project is located. The last two letters identify the modality as an alcohol safety school (AS) or a group therapy (GT) according to the a priori classification criteria discussed in the methods section. Different numerals indicate unique modalities for each project within each general classification. In Figure 5 individual rehabilitation modalities are plotted according to their approximate position in factor space for root 1. A clear discrimination between alcohol safety schools and group therapies is evident on this root.

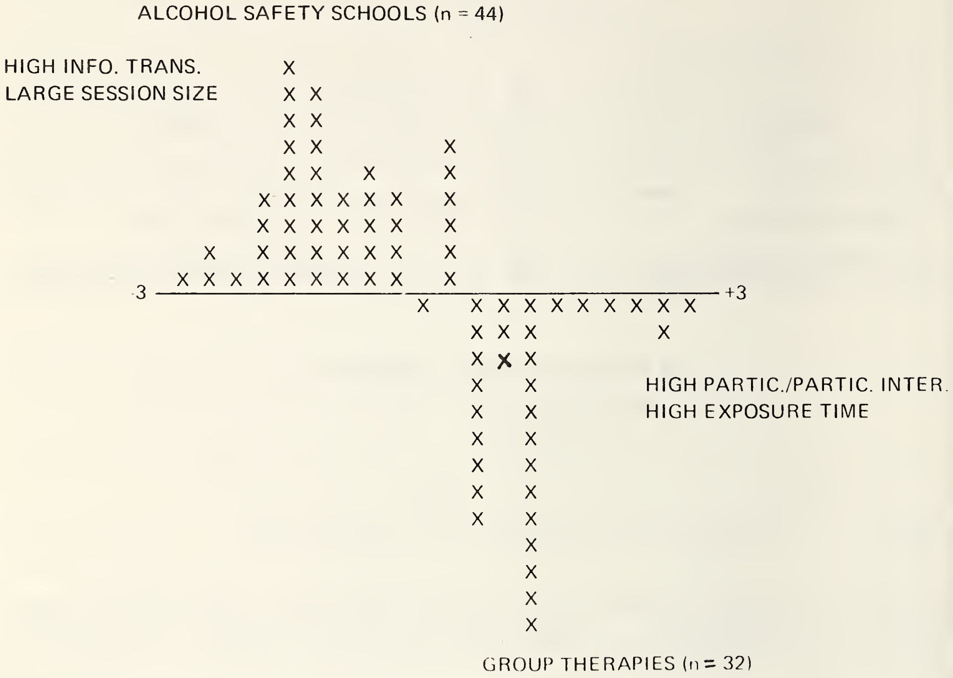
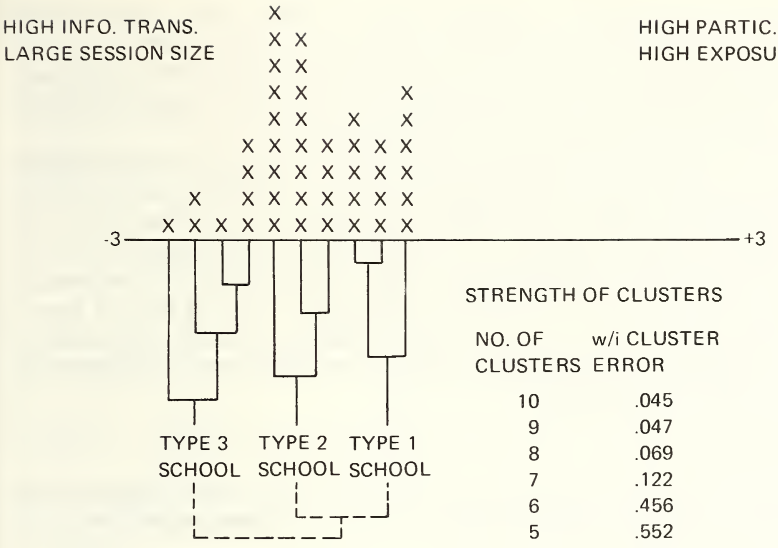


Figure 5 *Plot of Modality Factor Scores on Root 1*

Hierarchical cluster analysis. A hierarchical cluster analysis was performed on the factor scores for the alcohol safety schools (N = 44). The results of this analysis are portrayed graphically in Figure 6. Here the linkage tree diagram and the associated error at each level of the hierarchy are shown in relation to the approximate positions of the various alcohol safety schools on root 1. As is evident, the tree begins at the 10 cluster level and shows the stepwise merging of similar schools. As the within cluster error increases, the homogeneity of the groups, in terms of the qualities represented in the factor scores, decreases.

Again, the decision rule used in selecting the school types was to use the level with the fewest clusters where the next merging of the schools would result in a substantial increase in error. As is indicated in Figure 6 the within-group error in moving from three clusters to two clusters increases from 1.347 to 5.266. Thus the decision to stop the process at three clusters was made.

As an aid in interpreting the characteristics of the school types, the means of the profile variables were calculated for each type. Table IV shows the average profiles and average factor scores for root 1 school types. Type 3 schools spend on an average, 85 per cent of the time in retraining. There is only about 18 per cent of class time spent in participant-leader discussion, and virtually no time spent in participant-participant interaction. The total exposure time averages about 8 hours and the session size averages approximately 47 students.



STRENGTH OF CLUSTERS

NO. OF CLUSTERS	w/i CLUSTER ERROR
10	.045
9	.047
8	.069
7	.122
6	.456
5	.552
4	1.071
3	1.347
2	5.266

Figure 6 *Results of Hierarchical Cluster Analysis of School Types on Root 1*

TABLE IV *Means of Profile Variable Scores and Factor Scores for Root 1 School Types*

Variables	School Types Type 3	 Type 2	 Type 1
Information Transmission (% of Time)	85%	74%	51%
Session Size (No. Persons)	47	20	15
Partic./Leader Interaction (% of Time)	18%	34%	34%
Exposure Time (Hrs.)	8 HRS	11 HRS	18 HRS
Partic./Partic. Interaction (% of Time)	3%	12%	32%
Factor Score	-1.53	-.57	.20

On the other end of the first dimension, type 1 schools with positive factor scores allocate about half of the total exposure time to counseling activities, *i.e.*, the complement of information transmission. Both participant-leader and participant-participant interaction are present in approximately equal amounts. Session size averages 15 persons and the total exposure time averages 18 hours.

Type 2 schools engage in retraining activities 74 per cent of the total exposure time. The amount of time spent in participant-participant discussion, however, is as great as type 1 schools, *i.e.*, 34 per cent. There is an average of 12 per cent of the time spent in participant-participant interaction. The average total exposure time for type 2 schools is 11 hours, and the average session size is approximately 20 students. It appears that type 2 schools have a retraining orientation similar to that of type 3 schools, but, with a smaller class size, they appear to utilize a discussion approach for the presentation of drinking and driving information. The positions of the three school types on root 1 can be seen in Figure 7.

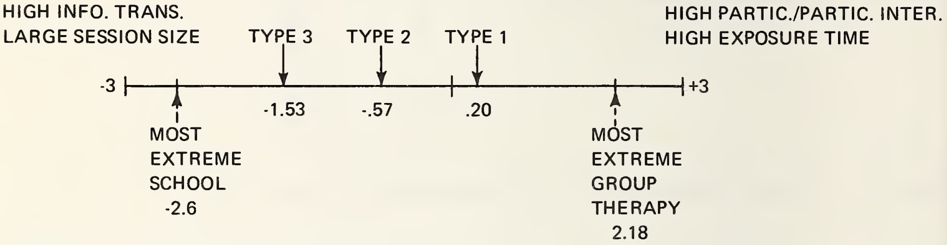


Figure 7 *Position of School Types on Root 1*

Analysis of Recidivism Rates for Drinker Types

Cumulative quarterly recidivism rates for problem drinkers and non-problem drinkers are shown in Figure 8. There appears to be a significant trend towards consistently higher re-arrest rates for problem drinkers than for non-problem drinkers, lending considerable credibility to the diagnostic process[9]. After the initial quarter, where only about 1 per cent of the problem or social drinkers recidivate, problem drinkers appear to have a quarterly recidivism rate of about 3-4 per cent and a 12 month rate of about 11 per cent for the first year after entry into treatment.

Non-problem drinkers, on the other hand, have a quarterly recidivism rate of only about 2 per cent and an annual (first year) rate of about 6 per cent.

Figure 9 shows the transformed arc sin cumulative rates for the two drinker types along with a summary of the results of the statistical analyses conducted on such data[10]. With regard to the profile analysis, only one of the three tests conducted (tests for slope, parallelness, and between group differences constitute this analysis) was relevant given the cumulative nature of the data. This test was the test for non-

[9] Some of the consistency between diagnosis and subsequent recidivism rates is due to the fact that the diagnostic process involves using prior DWI arrests as an indicator of problem drinking and subsequent arrests are more likely among persons with prior arrests than among those without such arrests.

[10] Summary results of the one-way analyses of variance conducted at each quarter period are shown here for convenience to the reader. It should be remembered that these tests were based on somewhat larger sample sizes (especially in earlier quarters) than was the profile analysis which included only schools with complete data for all exposure periods. Thus, the profiles varied slightly and were probably more stable with the larger samples.

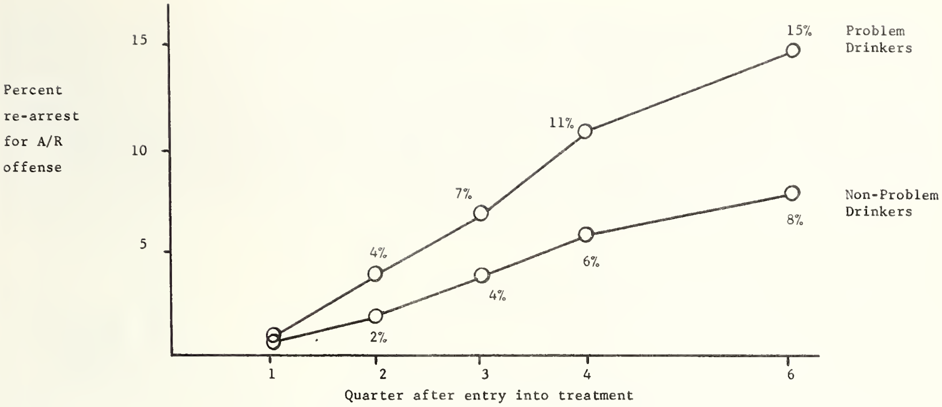


Figure 8 *Cumulative Quarterly Recidivism Rates for Problem and Non-Problem Drinkers*

parallel slopes and it was non-significant. Thus, it must be concluded that the slopes of the cumulative rates for the two drinker types remained similar over six quarters of exposure.

Again, since the data were cumulative in nature the finding of a significant slope would be expected. While the test for between group differences was also significant, the fact that it was conducted on cumulative-cumulative rates makes it difficult to interpret. More complete results for the profile analyses and the cumulative arc sin data are contained in Table V.

TABLE V *Summary of Profile Analysis of Variance*[a]

A. Results

Test of slope, non-zero scale means:
Wilks LAMBDA = .1964
F = 30.691 (df = 4 and 30)
$p < .001$

Test of parallel profiles:
Wilks LAMBDA = .7836
F = 2.071 (df = 4 and 30)
p = .109

Test of between group differences:
Mean square hypothesis = 4.0289
Mean square error = .6705
F = 6.009 (df = 1 and 33)
p = .019 ETA.SQ = .016

B. Mean Arc sin Cumulative Recidivism Rates

	Maximum Exposure Time in Quarter Years				
Drinker Type	1	2	3	4	6
Problem	.2013	.4124	.5470	.6776	.8031
Non-problem	.1677	.2868	.4170	.5138	.5771

[a] Change in arc sin cumulative recidivism rates over six quarters of exposure time for problem and non-problem drinkers.

Table VI shows the results of the individual one-way analyses of variance conducted on each quarter's cumulative rates. These tests are considerably more meaningful than the single test conducted by the multivariate program. As Table VI indicates there were significant differences (at the .05 level) between the two drinker types for two of the five intervals tested (*i.e.*, quarters two and six). The test at six quarters of exposure time is a test of the overall difference in profiles and the profiles are significantly different with 13.6 per cent of the variance attributable to the drinker type classification[11]. Again, especially in the early quarters, these tests were conducted on larger samples than was represented in the profiles.

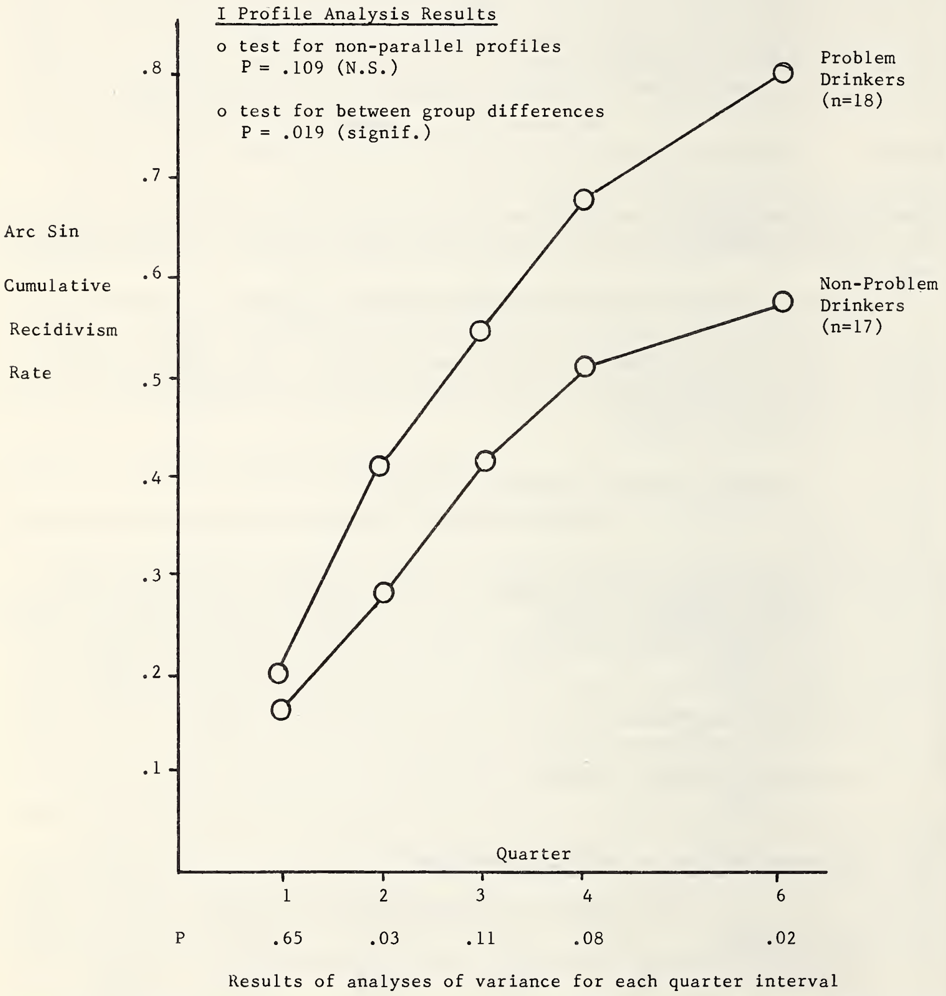


Figure 9 *Summary of Analyses of Variance on Cumulative Arc Sin Recidivisim Rate Profiles for Problem Drinkers Root 1*

Analysis of Recidivism Rates for School Types

Figure 10 illustrates the cumulative recidivism rate profiles for each school type according to the types of drinkers assigned to it. Here, again, problem drinker rates for every school type are higher than for non-problem drinkers. Further, there appears to be a trend toward higher recidivism rates for problem drinkers in the type 3 school (short session size, many participants per session, much time spent on information transmission, little participant-participant interaction). The first year recidivism rate for problem drinkers who attended the type 3 school was 15.2 per cent as compared with 11 per cent for problem drinkers in general. Problem drinkers in school type 1, however, had generally higher recidivism rates than in the type 2 school.

---

[11] One school in this analysis had only five quarters of exposure time.

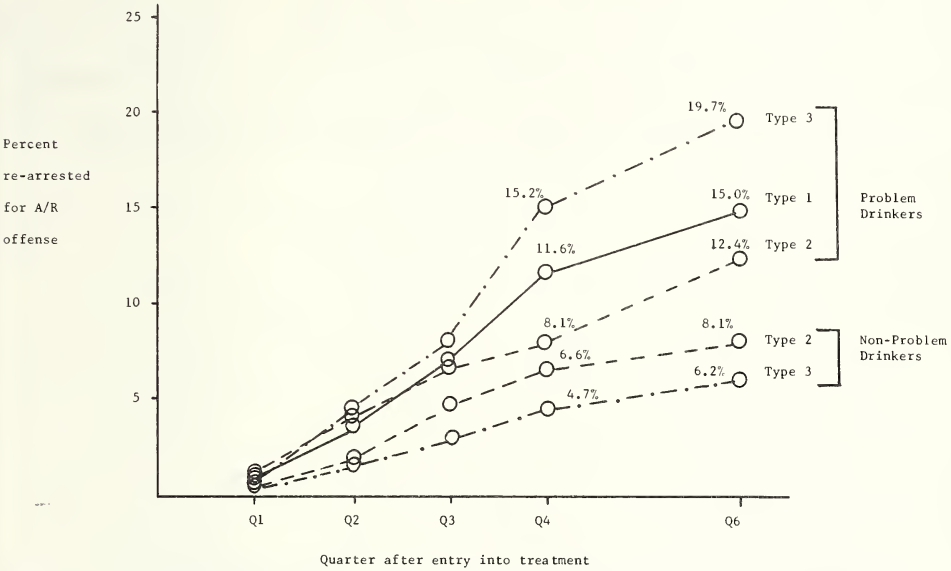


Figure 10 *Cumulative Quarterly Recidivism Rates for Each School Type by Drinker Type*

TABLE VI *Summary of One-Way Analyses of Variance between Drinker Types for each Exposure Period*

Results	1	2	3	4	6
Mean square hypothesis	.0154	.1760	.1216	.1679	.4464
Mean square error	.0174	.0336	.0455	.0539	.0688
F	0.885	5.232	2.670	3.114	6.487
df	1 and 44	1 and 43	1 and 38	1 and 35	1 and 33
p	.645	.026	.107	.083	.015
ETA. SQ	.003	.086	.040	.054	.136

With regard to the two school types which social drinkers attended[12] (types 2 and 3) the cumulative profiles are quite similar.

Figures 11 and 12 contain the arc sin cumulative rates and summary results of the profile tests conducted on these data for problem drinkers and non-problem drinkers, respectively. As with the analyses of drinker types, the tests for non-parallel profiles are most relevant, but were non-significant in both cases. Between group differences (based on cumulative-cumulative data) were not significant. Tables VII and VIII contain more complete summaries of the results of the profile analyses and the data on which they were conducted. The results of the two-way analyses of variance performed for each exposure period are summarized in Table IX. The test for overall between group differences at six quarters of exposure revealed no significant difference between school types. The four and six quarter tests were on type 2 and type 3 schools only because of a small sample size for type 1 schools. Tests on the other exposure periods also indicated no significant differences between school types.

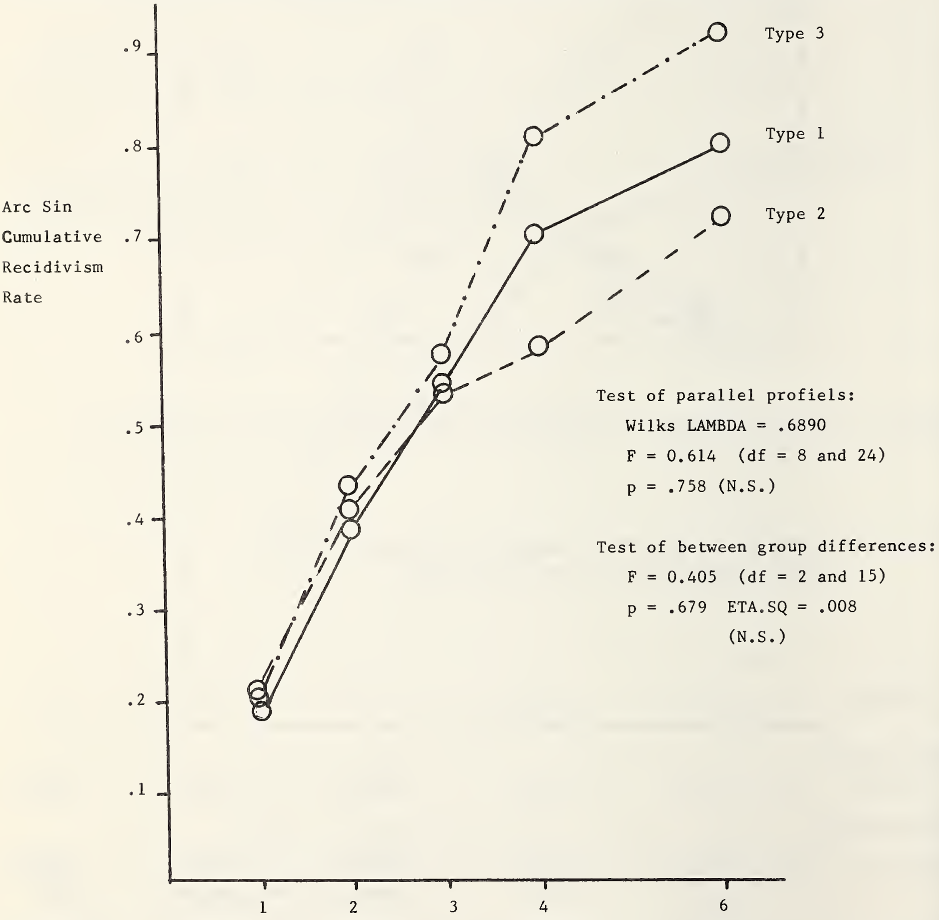
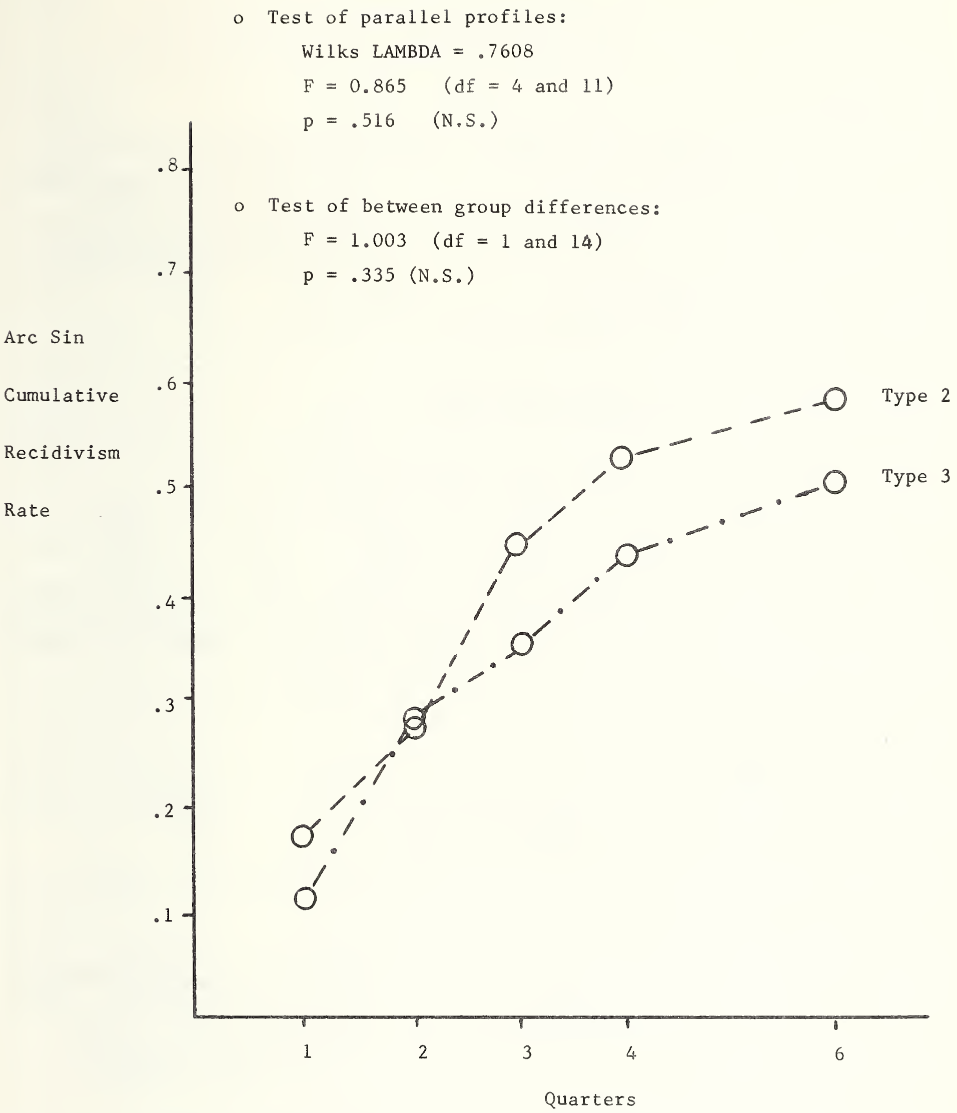


Figure 11 *Summary of Profile Analysis of Variance on Cumulative Arc Sin Recidivism Rates for Root 1 School Types: Problem Drinkers*

[12] Non-problem drinker rates for type 1 schools were not analyzed because of the small sample size in this category.


o Test of parallel profiles:
Wilks LAMBDA = .7608
F = 0.865 (df = 4 and 11)
p = .516 (N.S.)

o Test of between group differences:
F = 1.003 (df = 1 and 14)
p = .335 (N.S.)

Figure 12 *Summary of Profile Analysis of Variance on Cumulative Arc Sin Recidivism Rates for Root 1 Schools: Non-Problem Drinkers*

There was, however, a statistically significant interaction between school type and drinker type in the four quarters exposure interval. In a test of the simple effects, it was found that problem drinkers had a significantly higher recidivism rate than non-problem drinkers in type 3 schools (F = 5.240, df = 1 and 10, ETA.SQ = .261). There was no significant difference between drinker types in type 2 schools (F = 0.935, df = 1 and 10, ETQ.SQ = –.004). This drinker type by school type interaction, however, is not evident at six quarters of exposure time and therefore may be spurious.

TABLE VII *Summary of Profile Analysis of Variance*[a]

A. Results

Test of slope, non-zero scale means:
Wilks LAMBDA = .2092
F = 11.340 (df = 4 and 12)
p = .001

Test of parallel profiles:
Wilks LAMBDA = .6890
F = 0.614 (df = 8 and 24)
p = .758

Test of between group differences:
Mean square hypothesis = .3993
Mean square error = .9864
F = 0.405 (df = 2 and 15)
p = .679 ETA.SQ = –.008

B. Mean Arcsin Cumulative Recidivism Rates

	Maximum Exposure Time in Quarter Years				
School Type	1	2	3	4	6
1	.1885	.3859	.5396	.6962	.7959
2	.2105	.4093	.5302	.5757	.7197
3	.1976	.4342	.5742	.8011	.9191

[a] Change in arc sin cumulative recidivism rates over six quarters of exposure time for root 1 school types, problem drinkers.

TABLE VIII *Summary of Profile Analysis of Variance*[a]

A. Results

Test of slope, non-zero scale means:
Wilks LAMBDA = .0408
F = 64.723 (df = 4 and 11)
p < .001

Test of parallel profiles:
Wilks LAMBDA = .7608
F = 0.865 (df = 4 and 11)
p = .516

Test of between group differences:
Mean square hypothesis = .3256
Mean square error = .3248
F = 1.003 (df = 1 and 14)
p = .335 ETA.SQ < .001

B. Mean Arcsin Cumulative Recidivism Rates

	Maximum Exposure Time in Quarter Years				
School Type	1	2	3	4	6
2	.1757	.2785	.4433	.5212	.5762
3	.1285	.2812	.3516	.4347	.5042

[a] Change in arc sin cumulative recidivism rates over six quarters of exposure time for root 1 school types, non-problem drinkers.

TABLE IX *Summary of Two-Way Analyses of Variance for each Exposure Period: Root 1 School types*

SOURCE	*MS*	*df*	*F*	*P*	*ETA. SQ*
One Quarter					
Between Schools	.0324	2	1.887	.163	.038
Between Drinkers	.0269	1	1.562	.216	.012
Schools x Drinkers	.0129	2	0.075	.927	.040
Error	.0172	40			
Two Quarters					
Between Schools	.0130	2	0.364	.702	.027
Between Drinkers	.1957	1	5.491	.023	.097
Schools x Drinkers	.0055	2	0.153	.859	.036
Error	.0356	39			
Three Quarters					
Between Schools	.0267	2	0.569	.577	.021
Between Drinkers	.1645	1	3.500	.067	.062
Schools x Drinkers	.0183	2	0.389	.686	.030
Error	.0470	34			
Four Quarters					
Between Schools	.0379	1	0.990	.670	.001
Between Drinkers	.2416	1	6.318	.018	.137
Schools x Drinkers	.1741	1	4.554	.040	.091
Error	.0382	26			
Six Quarters					
Between Schools	.0370	1	0.634	.561	.010
Between Drinkers	.4759	1	8.162	.008	.188
Schools x Drinkers	.1319	1	2.263	.141	.033
Error	.0583	26			

DISCUSSION

Results of the Study Relative to the Need for Taxonomy

One of the requirements for the evaluation of rehabilitation programs, is a careful and systematic description of the programs under study. ASAP rehabilitation modalities are a heterogeneous population of educational-therapeutic techniques which attempt to impact the drinking-driving problem with positive behavior modifying approaches. It has been pointed out quite clearly that these approaches include a variety of combinations of retraining and counseling activities often designed for particular target groups. The recent use of such rehabilitation modalities in the area of highway traffic safety has not generally benefitted from a taxonomic structure within which to evaluate the relative effectiveness of various strategies. The development of such a taxonomy was addressed by this study.

A wide range of alcohol safety school structural characteristics was evident from the results of the principal components analysis. Furthermore, the alcohol safety schools appeared to be structurally different from the group therapy programs. Only one group therapy of the sample of 32, overlapped with the distribution of alcohol safety schools in the first factor space. The general structural differences indicated by this dimension reflect the relative emphasis of particular modalities toward retraining, counseling, or therapeutic functions. Schools with large negative factor scores perform, almost exclusively, a retraining function. As one moves toward the positive end of the continuum there is more discussion of factual material and the retraining function is supplemented more and more with group counseling activities. Finally, moving in the direction of high positive factor scores, one passes beyond the alcohol safety school distribution into more intensely therapeutic modalities.

The hierarchical clustering analysis defined three school types on the first factor root. Type 3 schools consisted of primarily retraining activities. They used a didactic approach and had large numbers of participants at each session. Type 2 schools consisted of slightly less retraining, with a smaller session size than type 3 and used participant-leader discussion to help convey information. Type 1 schools were approximately half counseling and half retraining oriented. They had the longest total exposure time, the smallest average session size, and they utilized substantial amounts of both participant-leader and participant-participant discussion.

The variety of alcohol safety schools suggests the possibility of matching school type modalities with drinker types. Such drinker types include both social drinkers and individuals in the early to middle stages of alcoholism. While a precise, diagnostic classification of drinker types was not available for the present study, an approximation to such a taxonomy, involving the use of standardized guidelines was provided.

Results of the Study Relative to Differences in Drinker Types

Only two broad categories of drinking drivers were included in this study. A profile analysis performed on the arc sin cumulative recidivism rates for problem and nonproblem drinkers entering alcohol safety schools, indicated that the slopes of the profiles were not significantly different. Consequently, the hypothesis that the two drinker types have different mean times to recidivism could not be supported from the data.

Problem drinkers, however, had a significantly higher mean recidivism rate after six quarters of exposure time. This significant difference between drinker type recidivism rates suggests that despite the broad and overlapping nature of the NHTSA reporting categories and despite interproject deviations from the classification criteria, problem drinkers have, on the average, a higher probability of recidivating than nonproblem drinkers within six quarters of exposure time.

Results of the Study Relative to Different School Types

The hypothesis that the school types, as they were defined in this study, had a differential effect on recidivism rates also could not be statistically supported. There were consistent trends for the type 3 school to result in higher recidivism rates for problem drinkers. If such a relationship actually existed, however, there apparently was a sufficient amount of 'noise' in the data to mask its effect, since the school type effect in the two-way analyses of variance performed on six quarter cumulative rates did not indicate significant differences.

From these results, it cannot be concluded that the schools, in general, had *no* effect on recidivism rate since no control group data were provided. However, the fact that no *differential* effect could be demonstrated between what were apparently quite different schools, does not add much support to any suggestion that the schools (by themselves) have such an effect. It appears that if a difference exists between the behavior modification potential of the various schools, arrest recidivism is not a very sensitive measure of such an effect. In fact one can make a strong case that recidivism rates calculated at the program level are insensitive measures of effectiveness.

Many differences exist between ASAP communities which could substantially affect re-arrest rates and contribute to within-group (error) variance at a program level. Large within-group error and small sample size would make it necessary to have very strong effects in order to obtain statistical significance. On the basis of site visits to each project, it would appear that substantial variance is contributed by the quality of the tracking systems and difficulties in searching records at ASAP sites.

Furthermore, considering the fact that only 11 per cent of the problem drinkers and 6 per cent of the non-problem drinkers recidivate in the subsequent year, it may be that life changes other than recidivism will have to be examined in order to determine the behavior modification potential of the various treatment modalities. In view of this possibility the NHTSA is placing more emphasis on the collection of life change data in the evaluation of some of the group therapy programs presently being implemented at ASAP sites. Future reports should contain the results of such efforts.

Need for Control Groups

It was necessary for the present study to attribute effects to school types on a post hoc basis. With such a design, one can never be certain that there was not a systematic bias in the assignment of participants to schools. Furthermore, as was pointed out, the lack of control groups limits conclusions to *relative* differences and not absolute effectiveness. The lack of control groups is not uncommon in the area of rehabilitation. The thought of random assignment aggravates the sense of ethics of most treatment persons, especially when the random assignment includes a no-treatment condition. Often this can be overcome by taking the time to discuss the issue with the treatment people. The best solution, however, involves conducting the assignment at the administrative or central referral level. Here, however, one often runs into opposition from project administrators.

It is only in well controlled demonstration projects that the effectiveness of school types, established on an a priori basis with randomly assigned participants, can be properly ascertained. The impact of Hawthorne effects and expectation effects can easily cause a project evaluation to show positive effects which have little to do with the treatment program itself. On the other hand, assignment of only the worst drinker types to particular modalities can easily cause such an evaluation to show negative results for the treatment program. The importance of random control group designs must be seen as being beneficial to all. However, in fairness to the treatment community, maximally sensitive measures to change must also be included even if they are not of *primary* concern to the agency supporting the demonstration program.

This Study as a Model

Finally, despite the inability of the present study to show that school types were differentially effective, the need for increased precision in the evaluation of rehabilitation efforts must be emphasized. The results of this study have shown that a broad range of activities and orientations exist under the single classification of alcohol safety school. One cannot hope to obtain consistent findings when the phenomenon under study is so diffuse in nature. Where positive results occur, they are unlikely to be replicated if the circumstances under which they occurred are vaguely defined. The methodology developed in this study demonstrated a systematic procedure for developing more clearly defined categories of rehabilitation modalities which are subject to evaluation procedures. Such categories represent the first step in the formulation of guidelines for the development of rehabilitation modalities in future demonstration projects. Those aspects of the present study which should be employed in future studies include:

1. The attempts to discriminate between different drinker types assigned to the various treatment modalities.
2. The attempts to identify the structural differences between various treatment modalities.
3. The close scrutinization of the criterion measures to be used in evaluating program effect.
4. The attempts made to standardize as completely as possible the guidelines for recording and reporting data.

Several other requirements exist for adequate program level evaluation. One of the most apparent and one which was not fulfilled by this study is the need for control group data. Also, the use of other, more sensitive measures such as life changes should prove more sensitive to the immediate effects of rehabilitation efforts. The design of future projects could also benefit from a refinement in drinker type classification. It is probably only through the pairing of specific drinker types with clearly defined modalities that treatment effects can be unambiguously demonstrated.

Evaluators have a responsibility to the treatment community as well as to administrators and other researchers.

Treatment people also conduct day-to-day evaluations of their clients. These evaluations consist of the therapist's interpretation of data from the client's reactions, activities, and life events. Systematic (or scientific) evaluation often seems counterproductive to these persons and is frequently perceived as an obstruction to the performance of their jobs. In the past, many research oriented evaluators have not tended to dissipate this feeling. In fact, they have often created new feelings of tension and prejudice between themselves and treatment people. Research results are often not presented to the therapists in a form which helps them. If told anything at all they are told only what is wrong. The inevitable competition between persons who see themselves as having different objectives results.

It is not clear whether this study deviates significantly from this pattern or not. However, it is hoped that these results, and others to follow, can be interpreted (and used) in a manner which improves the effectiveness of the rehabilitation area rather than in a way which hinders it.

APPENDIX A. Table 15 Recidivism
Data Reporting Forms and Instructions for Use

A SUMMARY OF THE REVISED GUIDELINES FOR COMPLETING TABLE 15

The following guidelines differ from existing Table 15 requirements in several important respects as a result of input from various evaluators and as a result of efforts by OAC to eliminate problems in last year's reporting procedure. The requested changes can be summarized as follows:

- Development of a consistent *definition of recidivism.* It is suggested that recidivism be defined in terms of *re-arrest* for an A/R traffic offense subsequent to *entry* into a rehabilitation or control category.
- Separate reporting of entry to rehabilitation or control conditions, and recidivism from these conditions, for the *three drinker type classifications* used in other Appendix H Table 14 (Problem Drinkers, Non-Problem Drinkers, and Unidentified). It is not possible to identify drinker classifications with the current Table 15.
- Provision of additional rows in the tables to permit reporting of *recidivism in one quarter intervals for the first year* subsequent to entry into rehabilitation or control conditions. Current data suggest that a substantial proportion of observed recidivism occurs during the first six month period after entry and it is felt that a more sensitive measure is necessary on the program level.
- Requirement of accurate and consistent *descriptions of rehabilitation countermeasures* used as column headings.
- Requirements of recidivism reporting for rehabilitation *dropouts.*
- Distinction between true random assignment control groups, and control groups formed on other than a random basis.

It is felt that these changes in format and reporting requirements are necessary for an adequate assessment of arrest recidivism rates on a national level.

INSTRUCTIONS FOR COMPLETING TABLE 15

There are *13 columns* on Table 15 in which to classify individuals. Six of these refer to rehabilitation modalities or combinations of modalities specified by each project. One column refers to all individuals *entering*** a rehabilitation modality *other than one of the six specified*. One column refers to individuals *not sentenced or referred* to any rehabilitation. One column refers to the *total number of individuals entering* treatment. One column refers to individuals referred to treatment *who do not* enter, and one to individuals *dropping out* of rehabilitation. Two columns refer to *control* groups. The column definitions on the following pages describe the requirements for inclusion of persons in these columns.

There are *nine row headings for each quarter*. The first of these refers to the *total number of individuals entering* rehabilitation during that quarter who fit the definition specified in column headings. The second row heading refers to the subset of individ-

---

**Analysis of recidivism for persons *completing* rehabilitation programs should be reserved for Analytic Study #6 if such analysis is desired.

uals in the first heading who *became recidivists* in the quarter in which they entered rehabilitation. The next three row headings refer to the subset of individuals in the first heading who became recidivists in the three subsequent one quarter periods following their entry into rehabilitation. The remaining three row headings for each quarter refer to the subset of individuals becoming recidivists in subsequent two quarter periods.

For the purposes of this table, a recidivist should be defined as follows: "any individual who subsequent to *enrollment* in a rehabilitation modality or combination of modalities (or subsequent to conviction for control and non-treated individuals or subsequent to dropping out of rehabilitation for individuals dropping out) is re-arrested* for an alcohol related driving offense." An individual should be classified as a recidivist whether the re-arrest* occurs *during* the course of treatment or *after* completion.

Observe the following conventions for individuals with *more* than one arrest* subsequent to enrollment in a rehabilitation modality or combination (or subsequent to conviction for non-treated and control individuals (or) subsequent to drop out for individuals dropping out of rehabilitation). 1) An individual should be included as a *recidivist only once* for each time through a particular treatment or treatment combination, i.e., if an individual is arrested* three times after entering a rehabilitation modality or combination, he should be counted as a recidivist only once unless further rehabilitation has been entered as the result of one of the recidivist arrests. 2) If an individual enters a rehabilitation modality or combination as the result of a recidivist arrest* he should be *treated as a different individual* both in terms of entry into treatment and in terms of future recidivism.

Column 1 – Total Not Referred to Treatment

This column should include all those individuals convicted of an alcohol related offense during the specified time periods who were 1) not referred to ASAP, *or* 2) referred to ASAP but not referred to treatment.

Column 2 – Total Entering Treatment

This column should include *all* those individuals entering rehabilitation during the specified time periods regardless of the eventual outcome. That is, this column should include both individuals referred or sentenced to treatment who did not enter treatment and individuals entering treatment. This column should be the sum of columns 3 through 11 if no control group was drawn from the set of individuals referred or sentenced to rehabilitation. This column should be the sum of columns 3 through 11 plus 13 if a control group was drawn from those individuals sentenced or referred to rehabilitation.

Column 3 – Total Dropouts

This column should include all individuals who entered rehabilitation but who subsequently dropped out of rehabilitation in the specified time period. This column should not include those persons who dropped out of rehabilitation as the result of becoming a recidivist. If an individual is sentenced or referred to multiple treatment modalities, he should not be included in this column unless he has dropped out of all modalities.

---

*If *necessary,* recidivism may be defined in terms of *re-conviction* for an A/R offense. If this change in definition is made it should be *prominently* noted on the table.

Column 4 – Total No Shows

This column should include all individuals referred to rehabilitation at a specified time period who failed to enter rehabilitation. If an individual was referred to multiple treatment modalities and *did* enter at least one, he should *not* be included in this column, but rather in the column of the treatment combination he entered.

*Columns 5 to 10 – Treatment Modalities**

Columns 5 to 10 should be headed with the six treatment modalities or treatment modality combinations most frequently used at your ASAP. These columns should include all individuals entering these modalities during the time periods specified and include: 1) those who are still enrolled in the treatment modality, *or* 2) those who have completed treatment, *or* 3) those who became recidivists while enrolled in the treatment modality (regardless of whether or not becoming a recidivist terminated treatment). These columns should be mutually exclusive. That is, a single individual should not appear in more than one of these six columns. An individual counted in one of these six columns should be included in no other column in the table except column two (total referred to treatment).

TABLE AI *Example of a Table 15 Sheet.*

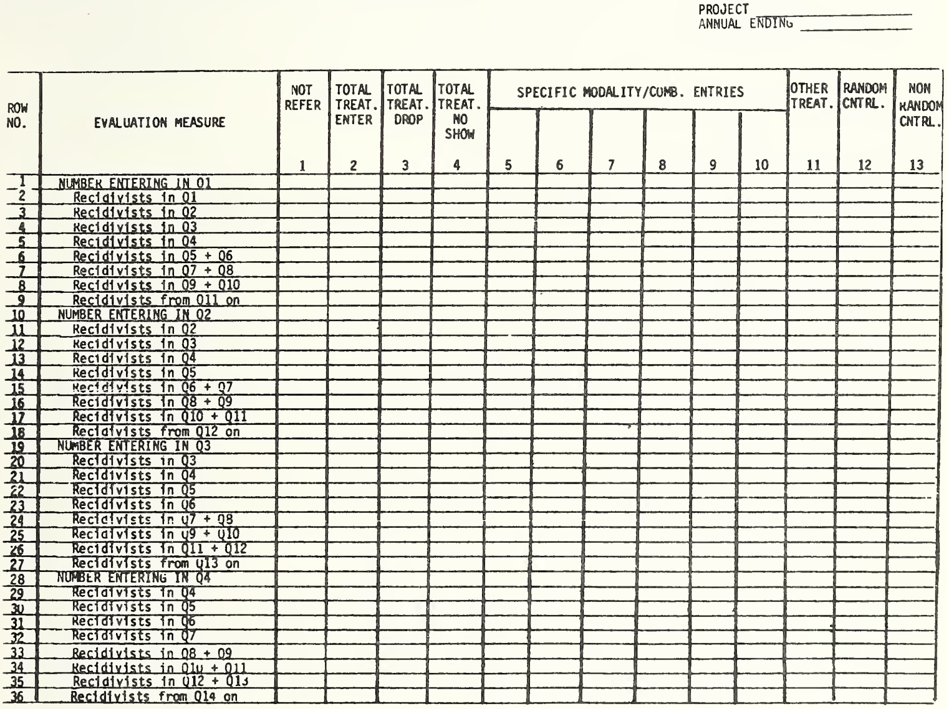


TABLE NO. 15A-1
PROJECT ____________
ANNUAL ENDING ____________

ROW NO.	EVALUATION MEASURE	NOT REFER	TOTAL TREAT. ENTER	TOTAL TREAT. DROP	TOTAL TREAT. NO SHOW	SPECIFIC MODALITY/COMB. ENTRIES						OTHER TREAT.	RANDOM CNTRL.	NON RANDOM CNTRL.
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	NUMBER ENTERING IN Q1													
2	Recidivists in Q1													
3	Recidivists in Q2													
4	Recidivists in Q3													
5	Recidivists in Q4													
6	Recidivists in Q5 + Q6													
7	Recidivists in Q7 + Q8													
8	Recidivists in Q9 + Q10													
9	Recidivists from Q11 on													
10	NUMBER ENTERING IN Q2													
11	Recidivists in Q2													
12	Recidivists in Q3													
13	Recidivists in Q4													
14	Recidivists in Q5													
15	Recidivists in Q6 + Q7													
16	Recidivists in Q8 + Q9													
17	Recidivists in Q10 + Q11													
18	Recidivists from Q12 on													
19	NUMBER ENTERING IN Q3													
20	Recidivists in Q3													
21	Recidivists in Q4													
22	Recidivists in Q5													
23	Recidivists in Q6													
24	Recidivists in Q7 + Q8													
25	Recidivists in Q9 + Q10													
26	Recidivists in Q11 + Q12													
27	Recidivists from Q13 on													
28	NUMBER ENTERING IN Q4													
29	Recidivists in Q4													
30	Recidivists in Q5													
31	Recidivists in Q6													
32	Recidivists in Q7													
33	Recidivists in Q8 + Q9													
34	Recidivists in Q10 + Q11													
35	Recidivists in Q12 + Q13													
36	Recidivists from Q14 on													

---

*A detailed description of what treatment is involved in each of the six columns should be provided. Abbreviations are *not* enough. In addition, references to documents in which there are complete descriptions of the modalities should be provided when possible.

*Column 11 – Other Treatments**

This column should include all individuals entering any treatment or treatment combination other than those specified in columns 6 to 10 during the specified time period: 1) who are still enrolled in treatment, *or* 2) who completed treatment, *or* 3) who became recidivists while enrolled in treatment. *All* individuals entering treatment who are not included in columns 5 to 10 should be counted in this column. Individuals counted in this column should be included in no other column of the tables except column 2 (total referred to treatment).

*Column 12 – Control (Random)***

This column should include all individuals randomly assigned to a group during the specified time periods.

*Column 13 – Control (Non-Random)****

This column should include all individuals assigned to a control group on a non-random basis during the specified time periods. This group may be made up of individuals randomly drawn from a larger group non-randomly assigned to a treatment modality. This group may be a subset of those individuals not referred to rehabilitation.

APPENDIX B Alcohol Safety School and Group Therapy Questionnaire

QUESTIONS FOR ALCOHOL SAFETY SCHOOLS AND GROUP THERAPY

1. Participants are led by:
   a. ___one individual
   b. ___two co-leaders
   c. ___three or more persons

2. Rate on the 10-point scale below to what extent the leader's role is that of teacher-instructor versus therapist-counselor.

   Instructor Counselor

3. The percentage of time utilized by the countermeasure to convey information (e.g., on drinking and driving) to participants is

   0 10 20 30 40 50 60 70 80 90 100

4. The percentage of time used to help participants with their social, emotional, and behavioral problems is

   0 10 20 30 40 50 60 70 80 90 100

   (Note: The sum of #3 and #4 should not exceed 100%)

---

*A detailed description of what these other treatments or treatment combinations are should be provided.

**A description of the random assignment procedures should be provided.

***The basis for assignment to the control group should be specified. A justification of the validity of the group as a control should be provided. If the group is a subset of individuals referred or sentenced to rehabilitation it should be prominently noted.

5. The percentage of time spent in didactic approaches such as providing lectures, films, guest speakers, etc., is

0 10 20 30 40 50 60 70 80 90 100

6. The percentage of time spent in discussion between participants and the leader(s) is

0 10 20 30 40 50 60 70 80 90 100

7. The percentage of time spent in discussion among the participants themselves is

0 10 20 30 40 50 60 70 80 90 100

(Note: the sum of #5, #6, and #7 should not exceed 100%)

8. The prescribed (standard) or average number of sessions attended is

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 ⩾25

9. The prescribed length of each session is

15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300

1 Hr. 2 Hr. 3 Hr. 4 Hr. 5 Hr. or more

10. The average number of participants attending the session is

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 ⩾40

REFERENCES

1. Bjrvner, K., An Evaluation of Compulsive Treatment Programs for Alcoholic Patients in Stockholm, With Particular Reference to Longitudinal Development, Epidemiological Aspects and Patient Morbidity, *Opuscula Medica* 25, 107 (1972).

2. Blumenthal, M. and Ross, H. L., Two Experimental Studies of Traffic Law, Vol. I, The Effect of Legal Sanctions on DWI Offenders, NHTSA Report DOT HS 800 826 Geomet Incorporated, Rockville, Maryland, February, 1973.

3. Borkenstein, R. F., Technical Content of State and Community Police Traffic Service. National Highway Safety Board, Washington, D.C. 1968.

4. Crabb, D., Gettys, T. R., and Stewart, E. L., Development and Preliminary Tryout of Evaluation Measures for Phoenix Driving While Intoxicated Reducation Program, Report prepared for PPG Industries Foundation, Arizona State University, Tempe, Arizona, 1971.

5. Filkins, L. D., Clark, C. D., Rosenblatt, C. A., Carlson, W. L., Kerlan, M. W., and Manson, H., Alcohol Abuse and Traffic Safety: A Study of Fatalities, DWI Offenders, Alcoholics, and Court-related Treatment Approaches. U.S. Department of Transportation, NHTSA Report for Contracts FH-11-6555 and FH-11-7129, Highway Safety Research Institute, University of Michigan, June, 1970.

6. Filkins, L. D., Mortimer, R. G., Post, D. V., and Chapman, M. M., Field Evaluation of Court Procedures for Identifying Problem Drinkers. U.S. Department of Transportation. NHSTA Report DOT HS 801 091, Highway Safety Research Institute, University of Michigan, May, 1974.
7. Goldstein, L. G., Driver Improvement: A Review of the Literature, California Traffic Safety Education Task Force Report. Sacramento, California, December, 1973.
8. Hill, M. J. and Blane, H. T., Evaluation of Psychotherapy with Alcoholics: A Critical Review, *Quarterly Journal of Studies on Alcohol,* 28, 76-104 (1964).
9. Joscelyn, J. D., and Jones, R. K., A Systems Analysis of the Traffic Law System: Summary Volume. U.S. Department of Transportation, NHTSA Report No. DOT HS 800 640, Institute for Research in Public Safety, Indiana University, October, 1971.
10. Joscelyn, K. B., Maickel, R. P., and Goldenbaum, D. M., The Drinking Driver: A Survey of Treatment Alternatives. U.S. Department of Transportation. NHSTA Report No. DOT HS 800 611, Institute for Research in Public Safety, Indiana University, October, 1971.
11. Kaestner, N., Research in Driver Improvement: The State of the Art, *Traffic Quarterly* 22 (4), 497-520.
12. Newman, J. R., McEachern, A. W. and Kirby, S., Drinking Drivers and Their Traffic Records, Draft Final report on NHTSA Contract DOT-HS-101-2-45, University of Southern California, 1974.
13. Overall, J. E. and Spiegel, D. K., Concerning Least Squares Analysis of Experimental Data. *Psychological Bulletin* 72, 311-322 (1969).
14. Panepinto, W. C., and Higgins, M. J., Keeping Alcoholics in Treatment: Effective Follow-through Procedures. *Quarterly Journal of Studies on Alcohol* 30, 414-419 (1969).
15. Pollack, S., Didenko, McEachern, and Berger, Drinking Driver and Traffic Safety Project. U.S. Department of Transportation, NHTSA Report No. DOT HS 800 699, Public Systems Research Institute, University of Southern California, May, 1972.
16. Sackman, H., Guidelines for Developing and Implementing Community Programs to Assist and Re-educate Drinking Drivers: Volume I. U.S. Department of Transportation, NHTSA Report No. DOT HS 800 634. Public Systems Research Institute, University of Southern California, January, 1972.
17. Sackman, H., Didenko, O., and Thomas, M., Community Demonstration Plan to Assist and Re-educate Drinking Drivers: Volume II. U.S. Department of Transportation, NHTSA Report No. DOT HS 800 635, Public Systems Research Institute, University of Southern California, January, 1972.
18. Seixas, F. A. and Hopson, A. L. The Effect of Rehabilitation on the Driving Behavior of Problem Drinkers, NHTSA Final Report, DOT HS-801-110, National Council on Alcoholism, New York, N.Y. July, 1973.
19. Smart, R. G., The Evaluation of Alcoholism Treatment Programs, *Additions* 17, (1): 41-51 (1970).
20. Stewart, E. I., and Malfetti, J. L., *Rehabilitation of the Drunke Driver: A Corrective Course in Phoenix, Arizona, for Persons Convicted of Driving Under the Influence of Alcohol.* New York, Columbia University Teachers College Press, 1970.
21. U.S. Department of Transportation. Alcohol and Highway Safety. A report to Congress from the Secretary of Transportation, 1968.
22. U.S. Department of Transportation. Alcohol Safety Action Projects – Evaluation of Operations – 1972: Volume II Detailed Analysis, Chapter 6 Evaluation of the Rehabilitation Countermeasure Activities. NHTSA Report No. DOT HS 800 874, Annual Report from the Office of Alcohol Countermeasures, 1974.
23. Veldman, D. J., *Fortran Programming for the Behavioral Sciences*. New York, Holt, Rinehart and Winston, 1967.
24. Voegtlin, W. L. and Le Mere, F., The Treatment of Alcohol Addiction: A Review of the Literature, *Quarterly Journal of Studies on Alcohol* 2, 717-803 (1942).
25. Wallace, D. L., Clustering, *International Encyclopedia of the Social Sciences,* 2, 519-524, Crowell, Collier and McMillan Inc., U.S.A., 1968.
26. Ward, H. J., Jr., Hierarchical Grouping to Optimize an Objective Function. *American Statistical Association Journal* 58, 236-244 (1963).
27. Morrison, D. F., *Multivariate Statistical Methods*. New York, McGraw-Hill, 1967.

Motor Claims of Abstaining Drivers

Åke Lindgren,[1]

Are total abstaining drivers involved in fewer road accidents than drivers who are not total abstainers and do total abstainers as a group show better claims results?

There is good reason to believe that total abstainers cause fewer accidents and have a better claims record. It is a well documented fact that drivers who have consumed alcohol run a much greater risk of accidents than other drivers. The degree of over-risk differs, but it is clear that the increase of the risk level commences with the consumption of very small quantities of alcohol. Total abstinence should therefore considerably reduce a driver's tendency to become involved in accidents. At the same time it should be recognized, however, that other factors directly connected with total abstinence contribute to the overall exposure of risk.

Motor accident statistics, gathered by the insurance companies from actual claims records, provide data on which observations can be made concerning the differences in claims frequencies and costs between total abstainers and non-abstainers. The purpose of this study is to analyse such statistics prepared by Swedish insurance companies and to summarize the results.

Expected Influence on Claims Cost of Drunken Driving

The conclusions of different studies, summarized in a report to the U.S. Congress by the Department of Health, Education and Welfare (1) indicated that excessive alcohol consumption contributed to 43% of the non-pedestrian traffic fatalities. "Excessive alcohol consumption" is interpreted to mean that the driver had a blood alcohol concentration of 0.05% or higher. The corresponding figure concerning personal injury accidents was 14% and for property damage accidents excessive alcohol consumption contributed to 7% of the accidents.

These figures can be used as a basis for calculating the claims cost attributable to alcohol, using insurance statistics as data. In Table I, the estimates are based on Swedish statistics. The total claims cost per year for motor accidents is approximately U.S. $200 million. In Sweden 2.3 million private cars are insured under Compulsory Third Party Liability conditions. Sixty per cent of these vehicles have comprehensive insurance covering accidental damage (with U.S. $125 Excess), fire, theft, glass-breakage and road-service. Another 25% of these motor vehicles are covered under a limited comprehensive policy, excluding accidental damage.

[1] Actuary, Ansvar Mutual Insurance Company, Stockholm, Sweden.

TABLE I *Estimated costs of Drunken Driving in Swedish Motor Insurance Accidents*

Class of claims	Private car claims cost 1971 Mill. US $	Accidents influenced by alcohol Per cent	Mill. US $	Per cent of total cost
CTP[a] fatalities	5	45	2.3	
CTP[a] other personal injuries	40	14	5.6	
CTP[a] property damages	45	7	3.2	
	90		11.1	12
Comprehensive policy[b]	60	7	4.2	
Acc. damage guarantee	20	7	1.4	
	80		5.6	7
TOTAL	170		16.7	10

[a] CTP = Compulsory Third Party Liability insurance.

[b] Comprehensive = accidental damage, fire, theft, glass-breakage, road service.

Motor vehicle traffic fatalities account for approximately 5% of the total cost of Third Party insurance claims, while other personal injuries account for 45% and property damage accounts for 50%.

The cost incurred for personal injury claims is constantly increasing over the years, due to amendments of the legislation, more liberal assessment of the claims as far as life annuities are concerned and the increasing cost of wages, which are taken into account in assessing a claim. As a result of this, the proportion of the claims cost attributable to drunken driving also has a tendency to increase proportionally.

The result of our study shows that accidents, where motor vehicle drivers have a blood alcohol level of 0.05% or more account for 10% of the total claims cost or about U.S. $17 million per year.

Expected Reduction in Claims Cost for Total Abstainers

The figures referred to above can also be used to calculate corresponding cost reduction in motor insurance claims statistics for total abstainers. If non-drinking drivers are considered as a special group of policyholders and if their claims results are compared with non-abstaining policyholders it can be expected that the claims cost per policyholder will be about 10% lower for the non-drinking drivers, provided that all other factors remain equal.

Studies in Sweden 1933-1955

The experiences of insurance business in Sweden over a number of years, as expressed in statistics uniformly compiled, have provided an opportunity of assessing whether any differences really exist between the two groups of drivers, *i.e.* between total abstainers and non-abstainers. Since 1933 Ansvar Mutual Insurance Company has issued insurance policies only to total abstainers, *i.e.* persons who declare that they abstain from beverages with an alcohol content in excess of 2.25% alcohol by volume. Compulsory Third Party Liability motor insurance statistics are used as the basis of our comparison. Because of the uniformity in reporting to the Swedish Insurance Inspectorate by individual insurance companies, this study has been based on the number of claims compared with the number of insurance policies currently in force.

Calculations in respect of the periods 1933-1946, 1947-1950 and 1951-1955 showed that the claims ratio for Ansvar's policyholders was significantly lower than that of policyholders with other insurance companies. This applied on an average over the whole range of insurance business and in respect of individual classes of risks. In the case of private car insurance, the largest individual class of risks, it was found that the difference remained fairly stable at 15-20%.

Analysis of Results 1957-1972

The comparison of claims experiences has been extended by an analysis of similar statistics covering the period 1957-1972, a period which is interesting in several respects. The Swedish insurance business expanded very considerably during these years and the competition between insurance companies was very fierce. The number of private cars insured (the particular class of business covered by this report) increased by 170% from 826,000 in 1957 to 2,230,000 in 1972.

In 1957 all other insurance companies in Sweden introduced special discounts to total abstainers, by forming special insurance groups for non-drinking policyholders. The combined total of policyholders in Ansvar and in the special groups for total abstainers formed by other insurance companies was 122,000 in 1957 (of which Ansvar policyholders accounted for 98,000) compared with 276,000 in 1972 (when Ansvar had 156,000 policyholders). As a result, studies and comparisons can be made on very substantial numbers of policyholders in respective groups. The basic statistics used in this study are taken from official statistical reports compiled by the Swedish Insurance Inspectorate and covering Third Party motor vehicle insurance.

Methodological Problems

In order to ensure a fully representative comparison between total abstainers and non-abstainers a number of factors have to be taken into consideration, as there are many variables which influence the risk of a driver becoming involved in accidents. Numerous studies show that there are significant relationships between motor accidents and such variables concerning the driver as sex, age, marital status and occupational level. Other potentially important variables are religious affiliation, educational level, social and economic status, social stability/instability, social mobility and leisure activities. Other driving variables such as previous accidents, driving experience and driving exposure must also be taken into consideration (1).

The Swedish motor insurance companies have taken most of these important variables into account in a well diversified tariff system. All motor insurance companies in Sweden use the same tariff system and cooperate in a unique way, both in preserving and developing this uniform tariff system. The Swedish motor insurance market also has close cooperation in analysing claims statistics annually for the specific purpose of assessing the importance of each variable individually and for the tariff system as a whole. The most important variables of the Swedish tariff system are:

1. No claim bonus
2. Driving distance/annual mileage
3. Make and model of the motor vehicle
4. Age of the vehicle
5. Age of the driver/s
6. Geographical area of use

In analysing claims histories motor vehicle claims are strictly separated under the following headings:

1. Third Party liability claims
2. Accidental damage claims
3. Fire-claims
4. Theft-claims
5. Glass-breakage-claims

TABLE II *Motor Third Party insurance Sweden, private cars, number of vehicle years and NCB-reduced claims frequency.*

Rating area S = Stockholm, Gothenburg, Malmö, N = Northern Sweden, Ö = Sweden outside Northern Sweden and the three biggest cities.

	ANSVAR		NON TEMPERANCE POLICYHOLDERS		QUOTA
Year	No. of veh. years in thousands	NCB-reduced claims freq. 0/00	No. of veh. years in thousands	NCB-reduced claims freq. 0/00	(3)/(5)
1	2	3	4	5	6
Rating area S = Stockholm, Gothenburg, Malmö					
1957	11	177	161	200	0.88
1958	14	186	181	220	0.85
1959	16	200	198	223	0.90
1960	17	216	220	230	0.94
1961	18	241	242	268	0.90
1962	19	255	255	291	0.88
1963	19	261	265	294	0.89
1964	20	256	319	282	0.91
1965	21	297	347	301	0.99
1966	22	273	370	297	0.92
1967	22	223	390	259	0.86
1968	23	221	410	236	0.94
1969	24	219	436	233	0.94
1970	25	225	458	237	0.95
1971	25	(219)		(232)	(0.94)
1972	26	(189)		(210)	(0.90)

Table II continued

	ANSVAR		NON TEMPERANCE POLICYHOLDERS		QUOTA
Year	No. of veh. years in thousands	NCB-reduced claims freq. 0/00	No. of veh. years in thousands	NCB-reduced claims freq. 0/00	(3)/(5)
1	2	3	4	5	6
Rating area N = Northern Sweden					
1957	18	72	99	92	0.78
1958	20	87	110	101	0.86
1959	22	93	121	113	0.82
1960	24	104	134	117	0.89
1961	25	125	147	138	0.90
1962	24	143	157	164	0.87
1963	24	144	157	169	0.85
1964	23	148	177	164	0.90
1965	24	184	188	196	0.94
1966	25	187	199	189	0.99
1967	26	139	211	164	0.85
1968	27	137	221	154	0.89
1969	27	143	234	150	0.95
1970	28	140	244	151	0.93
1971	28	(142)		(147)	(0.97)
1972	29	(123)		(134)	(0.92)
Rating area Ö = Other parts of Sweden					
1957	63	68	426	85	0.80
1958	70	90	496	104	0.87
1959	78	87	543	105	0.83
1960	85	102	601	121	0.84
1961	87	119	662	144	0.83
1962	84	142	748	183	0.78
1963	85	157	784	174	0.90
1964	86	150	753	168	0.89
1965	89	182	820	190	0.96
1966	92	179	873	192	0.93
1967	94	131	929	157	0.83
1968	96	144	976	150	0.96
1969	96	148	1,045	149	0.99
1970	97	150	1,096	149	1.01
1971	98	(147)		(153)	(0.96)
1972	99	(141)		(146)	(0.97)

In this study it has been possible to use data compiled from both official and unofficial statistics, in order to equalize other factors and to compare objectively the differences between total abstainers and non-abstainers.

No claim bonus (NCB). The NCB-system in Sweden is very extensive and capable of equalizing the premium level between policyholder with a different claims experience. To exemplify this it can be pointed out that in Third Party Liability Insurance (CTP) a policyholder without any NCB is paying a premium which is four times as great as the premium paid by a policyholder with the maximum NCB. In consequence with this system, divided into seven NCB-levels, a policyholder incurring a claim is penalized by a premium loading amounting to 20% of his discount during the succeeding term of insurance. This will accumulate to a premium loading of 120-140% over the six year cycle of the NCB-system. In addition policyholders incurring more than one claim during one year are penalized by having to pay two or three times the current premium during the subsequent period of insurance.

The NCB-system is designed in such a way as to incorporate the most important biological and technical variables as well as driver characteristics indicated above.

Our analyses are based on a method adopted by Swedish actuaries for studies of this kind. The findings are based on the number of policies under yearly exposure – *i.e.* vehicle years – and have been corrected for NCB-discounts. This means that a policy with 75% NCB is calculated as 0.25 vehicle years and a policy with 0% NCB is calculated as 1.0 vehicle year. The presumption in calculating claims frequencies is then that a policy with a 0% NCB discount will incur a claim level which is four times greater than for a policy with 75% NCB discount.

The NCB system tends to equalize total abstainers with non-abstainers in terms of premiums. This is an important factor, because the number of total abstainers receiving a high NCB-discount is greater than the non-abstainers.

Geographical areas. Weather conditions, especially during the winter-time, and traffic density in different parts of Sweden have a strong influence on the accident risk. This has been accounted for in the tariff system and Sweden is divided into three areas:

1. The three biggest cities in Sweden, *i.e.* Stockholm, Gothenburg and Malmö, constitute one area. This area has the highest claims frequency and the highest claims cost per policyholder.
2. The north of Sweden constitutes another area. Claims frequencies and cost are influenced by the climatic conditions with long winters and consistently heavy snow-cover.
3. The third tariff area is made up of the remaining parts of Sweden, excluding Stockholm, Gothenburg and Malmö and the northern part of Sweden.

Twenty-five per cent of all policyholders reside in the city area, 15% in the northern area and 60% of all policyholders reside in tariff area 3. (Table II)

Driving distances/annual mileages. The tariff is divided into five mileage classifications and the premium is estimated on an annual mileage estimation made by the policyholder. The lowest mileage classification is for driving distances up to 10,000 kilometers and the highest mileage classification is for driving distances above 25,000 kilometers annually. The policyholders driving more than 25,000 kilometers annually pay a premium which is 50% higher than for policyholders having an annual mileage of up to 10,000 kilometers annually.

Make and model of the vehicle. There are great differences both in claim frequency and average claims cost between different makes and models of motor vehicles. The Swedish tariff system for motor vehicle insurance is based on a calculation of claims statistics per make of vehicle and the vehicles are grouped in different premium classifications. Premiums for compulsory Third Party insurance are calculated in accordance with ten different classifications based on make/model of the insured vehicle. The premium difference between the lowest classification and the highest classification is 125%. The number of classifications and the premium differences are even greater for comprehensive motor vehicle insurance.

Knock-for-knock agreement. Increasing importance attaches to the extent of damages incurred in collisions between vehicles driven by total abstainers and non-abstainers. This is because Swedish insurance companies have a mutual agreement to share the cost equally for damage on vehicles involved in collisions in order to avoid time-consuming and costly investigations to determine responsibility in individual cases. This knock-for-knock agreement applies to damages up to an amount of U.S. $1,400.

Due to the fact that an increasing number of motor vehicle owners have taken out comprehensive insurance policies for their vehicles, the knock-for-knock agreement has come into more common use and the number of cases settled accordingly has increased. The 50/50 basis of sharing the claims costs for such accidents, does not take into account that total abstainers involved have a lower degree of responsibility. Studies carried out by Ansvar and covering a number of years, have given indisputable evidence on the fact that the degree of responsibility is lower for total abstainers than for non-abstainers. Regardless of whether total abstainers are responsible or not, the knock-for-knock agreement on a 50/50 basis will result in a claim both on the group of total abstainers and on the group of non-abstainers. In order to correctly determine the risk levels for total abstainers as compared with non-abstainers, the knock-for-knock agreement must be subject to special studies concerning the responsibility for claims, in order to arrive at the proper determination of the risk difference between total abstainers and non-abstainers.

Other factors. The comparisons covered by this study are mainly concerned with the compulsory motor insurance claims, *i.e.,* Third Party, personal injury, or property claims. Some data concerning accidental damage claims are, however, also included. The number of policies referred to in the survey is the annual average of policies in force during the year. The number of claims referred to in the survey are only claims paid or claims outstanding as per 31st December, two years after the year of the accident, (e.g. claims occurring in 1970 paid or outstanding as per 1972-12-31). The study is limited to compare differences in claim frequencies, or the quotient between the number of policy years and the number of claims. Since the average cost per claim is the same in both groups the difference in frequency can be converted accordingly to express the claims ratio.

Result of Studies 1957-1972

The studies give conclusive indication that the claims frequencies for total abstainers is lower year by year than the claims frequencies for non-abstainers. In view of the fact that the studies are made on the entire data base and not on samples thereof and since the statistical material is substantial in each area covered by the tariff, the difference which is statistically significant is small as indicated in Figure 1 and Table III. The balanced average for the entire period 1957-1972 shows that the claims ratio is 10% lower for the total abstainers than it is for the general group. This confirms the findings of previous studies, which have also proved that there is a very clear difference in the risk between total abstaining drivers and other drivers. This also confirms the presumption made earlier in this paper that there is a 10% lower claims cost for total abstainers, due to the influence of drunken driving on the claims cost. A certain leveling out in claims frequencies appears to have occurred during recent years. It has been proved that this situation can be explained by the fact that Ansvar has become a party to the knock-for-knock agreement and the effect it has had on leveling out differences in claims frequencies, as has been pointed out earlier. If the claims frequencies are corrected accordingly, the average quotient for the period 1957-1972 is 0.90 and the difference of 10% in claims ratio consequently applies to the entire period under review.

TABLE III *Quota between NCB[a]-reduced claims frequency of temperance policyholders (Ansvar) and non temperance policyholders in other Swedish companies*

Year	Stockholm, Gothenburg, Malmö	Northern Sweden	Sweden outside the three biggest cities and Northern Sweden
1957-1961	0.89	0.85	0.83
1962-1966	0.92	0.90	0.89
1967-1972	0.94	0.93	0.96
Tot. 1957-1972	0.92	0.89	0.89

[a] NCB = No claims bonus discount.

It is perhaps of interest to note the change in claims frequencies which has occurred over the years in Sweden. As is shown in Figure 1, claims frequencies have increased year by year from 1957 to 1965. In areas outside the large cities (Stockholm, Gothenburg, Malmö) claims frequencies were doubled and in the large cities claims frequencies increased by almost 50%. The main reason for this is the sharp increase in the number of vehicles, increased traffic intensity and increased use of vehicles.

The reduction in claims frequencies from 1965 is due to many causes. Different legislative efforts to regulate the traffic and repeated information drives have had a significant effect. Speed limits have been introduced during this period and compulsory motor vehicle testing has resulted in an increased quality standard of the motor vehicles. In addition, selected measures introduced by the insurance companies, a new tariff system and changed regulations of no claim bonuses has also helped to reduce the motor vehicle claims.

It is of interest to note that total abstainers insured an abstinence groups with other insurance companies also have lower claims frequencies on average than non-abstainers. For the period 1957-1972 the average claims frequency for total abstainers insured in special abstinence groups with other companies was on average 6% below the general group. Our studies do not indicate any difference between the groups compared, concerning such variables as annual driving distance, make and model of the motor vehicle, as these factors do not appear to have any influence on the claims frequency differences between the two groups.

The differences in claims frequencies are also present in comparisons of other types of claims than traffic claims. This is apparent mainly in such claims as accidental

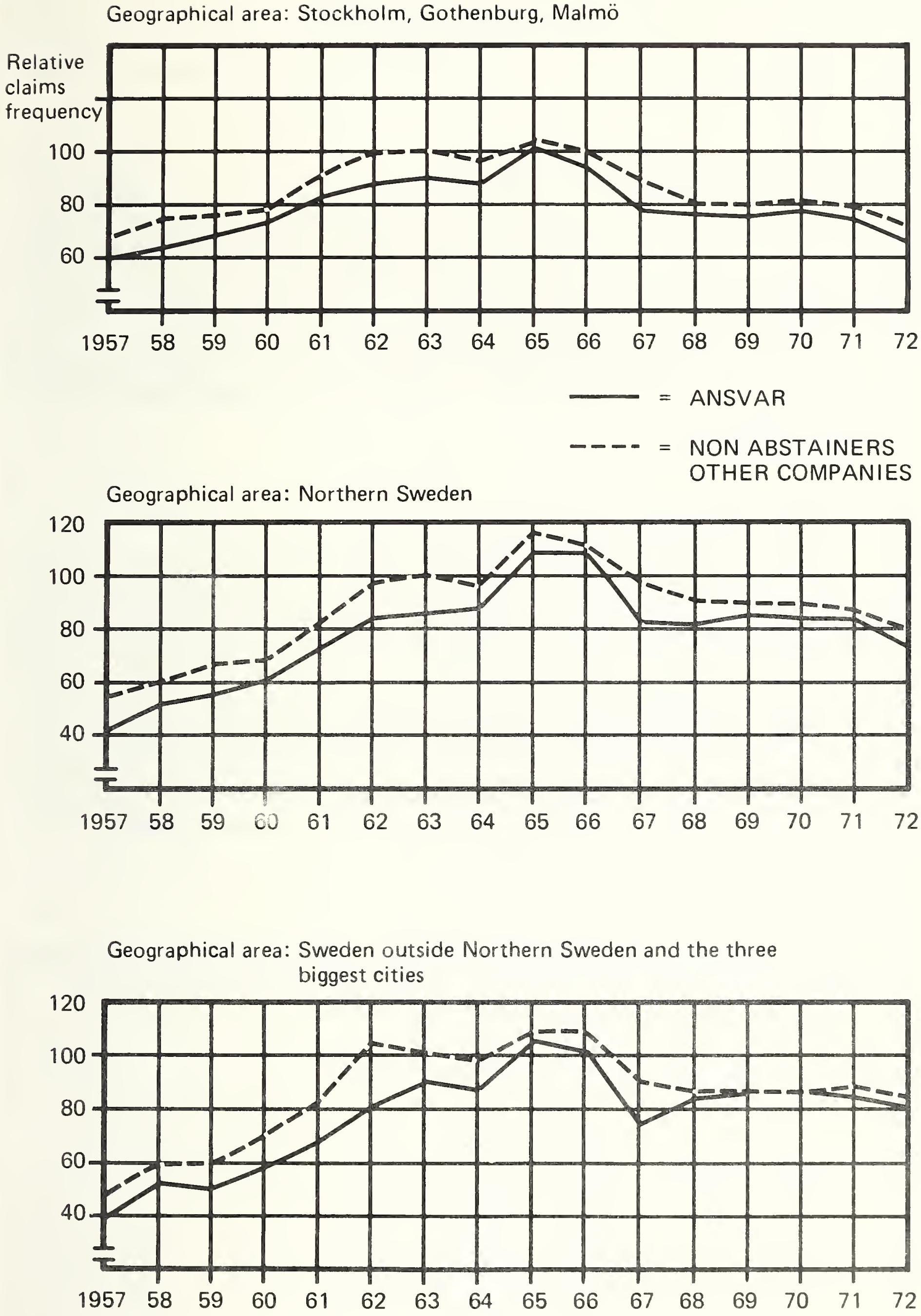


Figure 1 *Claims Frequency in Third Party Liability Policy, 1957 – 1972*

damage claims, *i.e.*, claims where the insured is claiming under the material damage section, but the same applies to fire, theft and glass-breakage. The only conclusion which can be drawn is that a total abstainer is exposing himself to less risky situations than non-abstaining policyholders. This fact is reflected in claims comparisons between the two groups.

International Comparisons

During recent years it has been possible to make comparisons between the claims experiences of Ansvar policyholders on the one side and other companies' policyholders on the other hand, concerning claims frequencies in some countries outside Sweden. The countries concerned are Great Britain and Finland. Based on the statistical data which are available, it is clear that total abstaining policyholders, insured in Ansvar group companies in Great Britain and Finland, have a claims frequency which is 10-15% below the claims frequencies of non-abstaining policyholders insured in other companies.

SUMMARY

Surveys from different countries clearly indicate the effect of alcohol as a causative factor in connection with traffic accidents. The findings of these studies are sufficient to indicate that there is a difference in claims frequencies between total abstaining drivers and non-abstaining drivers. The Ansvar Group of insurance companies, insuring total abstainers only, shows a consistent pattern in every country where the company is working and where the statistical data are available for comparisons, of a lower claims frequency than other insurance companies. The favourable difference is approximately 10%. In the comparisons which have been made due consideration has been taken of such factors as no claim bonus, annual mileage, make and model of the motor vehicle and of such other factors which constitute differences in the composition of the respective groups.

REFERENCES

1. U.S. Department of Health Education and Welfare, Public Health Service. Second special report to the U.S. Congress on Alcohol and Health, reprint edition June 1974, p. 53.

Author Index[1]

Aschoff, Jurgen C. 319
Bailey, Keith 453
Baker, William E. 129
Becker, Wolfgang 319
Betts, T. A. 415
Birrell, J.H.W. 775
Blumenthal, Murray 755
Bø, O. 439
Bonnichsen, Roger 495
Borkenstein, Robert F. 51, 655
Bredesen, J. E. 439
Breen, Martin H. 549
Brown, Peggy A. 181, 749
Bullaboy, Marilyn M. 597
Burford, R. 423, 433
Carr, Brian R. 679
Chambers, Larry W. 689
Chappel, C. I. 365
Chesher, G. B. 461
Clayton, A. B. 415
Codling, P. J. 73
Coldwell, Blake B. 453
Craig, John 771
Cunliffe, A. 869
Curry, A. S. 469
Dubowski, Kurt M. 483
Dussault, P. 365
Farbar, C. M. L. 679
Farmer, Philip J. 831
Fee, Dwight 789
Fine, Eric W. 169
Finkle, Bryan S. 607
Finn, Peter 881
Forney, Robert, Jr. 613
Fox, Bernard H. 51
Frankenhaeuser, Marianne 259
Franks, H. M. 461
French, I. W. 423, 433
Gambart, Roger 405
Goldberg, H. 679
Goodstadt, M. 869
Haffner, J.F.W. 449
Hames, Lee N. 861
Harger, Rolla N. 583
Harris, Lawrence S. 561
Harvey, P. G. 415
Havard, J.D.J. 637
Hawthorne, R. T. 709
Hensley, V. R. 461
Hensley, W. J. 461
Hetzel, B. S. 717
Hieatt, D. 869
Hoday, John 699
Hodnett, C. Nicholas 561
Hoeft, G. 305
Holman, Martin 175
Homatidis, S. 371
Hopson, Anna Lee 723
Hossack, Donald W. 825
Hudson, Page 597
Hutson, Don 533
Hughes, E.S.R. 717
Irgens-Jensen, Olav 159
Jackson, D. M. 461
Jain, Naresh C. 619
Joling, Robert J. 855
Jones, A. W. 509
Jones, T. P. 509
Kalant, H. 371
Kapur, B. M. 69, 627
Karras, L. 305, 527
Kaye, Sidney 85
Kielholz, P. 395
Kier, Lawrence C. 623
Kobayashi, Minoru 313
Kornaczewski, Alexander 239, 763
Langard, Ø 439
Langford, Nanci 771
LeBlanc, A. E. 371, 423, 433, 449
Levett, J. 305, 527
L'Hoste, Jean 889
Lindgren, Åke 927
Lonero, L. 869
Lunde, P. K. M. 439
MacArthur, Carol 771
Machata, G. 541

---

[1] The address of the presenting author is given as a footnote on the first page of each paper.

Malfetti, James L. 737
Mason, Morton F. 533
May, Gerald W. 129
MacBay, Arthur J. 597
McDermott, F. 717
McLaughlin, L. 627
McLellan, James K. 705
Mortimer, R. G. 329
Moskowitz, Herbert 295, 399
Mullen, John B. 561
Mulligan, Michael J. 169
Murray, James 399
Nichols, James L. 893
Noordzij, P. C. 33, 553
Palmer, Sidney 175
Pang, H. 869
Pearce, Dan S. 549
Pierce, J. 869
Perrine, M. W. 107, 199
Reinhardt, Gunther 579
Reis, Raymond E. 893
Repa, B. S. 347
Roberts, Robin S. 689
Robinson, Ann E. 573
Ross, H. Laurence 663,755
Ryan, G. A. 717
Sabey, Barbara E. 73
Sandler, Irwin 175
Santamaria, J. N. 381
Saunders, A. Bryan 845
Schmidt, Wolfgang 763
Schurr, Bryce C. 181, 749
Scoles, Pascal 169
Seixas, Frank A. 723
Sellers, Edward M. 271
Selzer, Melvin L. 13
Siler, K. F. 549
Simon, Kenneth J. 737
Smiley, A. 433
Solarz, Artur 389
Stanton, Bruce 771
Starmer, G. A. 451
Sterling-Smith, Robert S. 93
Sturgis, S. P. 329
Sunshine, Irving 613
Swinehart, James W. 799
Tamerin, John S. 249
Tennant, Jean A. 347
Thomas, Barry H. 453
Thompson, R. R. 347
Trumpy, J. H. 439
Turk, Robert F. 597
van Keer, Etienne 405
VanNote, Wallace E. 619
Verhaegen, Paul 405
Voas, Robert B. 21
Voelker, Cameron C. 689
Waller, Julian A. 3
Weinert, Dieter 319
Whitehead, Paul C. 771
Wilde, G.J.S. 813
Wilson, A. 371, 449
Wolfe, Arthur C. 41
Woodhouse, E. J. 147
Wright, B. M. 509
Wynkoop, Robert 175
Zelhart, Paul F., Jr. 181, 749
Zinc, Peter 579
Zylman, Richard 225

Acknowledgements

The Organizers of the Conference would like to express their thanks to the following organizations and individuals for their generous financial assistance, without which it would have been impossible to hold this Conference.

Les organisateurs du Congrès aimeraient remercier les organisations et individus suivantes pour leurs assistances financières, sans cette aide cette Conférence n'aura pas eu lieu.

Alberta Gas Trunk Line Company Limited
Alliance Compagnie Mutuelle d'Assurance-vie.
Aluminum Company of Canada Ltd.
Andres Wines Ltd.
Banque Canadienne Nationale
Bell Canada
B.F. Goodrich Canada Limited
BP Canada
Birks Family Foundation
Canada Wire and Cable Limited
Canadian General Electric Company Limited
Canadian International Paper Company
Canadian Pacific Rail
Cassiar Asbestos Corporation Ltd.
Champion Spark Plug Company of Canada Ltd.
Chrysler Canada Ltd.
Credit Foncier Franco-Canadien
Consumers' Gas Company
Dominion Foundries and Steel Limited
Dominion of Canada General Insurance Company
Dow Chemical of Canada Limited
Du Pont of Canada Limited
Eaton's of Canada Limited
Empire Life Insurance Company
Fiberglas Canada Limited
Foster Wheeler Limited
General Motors of Canada Limited
Gilbey Canada Limited
R.M.P. Hamilton
Honeywell Limited
Imasco Limited
Imperial Oil Limited
International Nickel Company of Canada
Industrial Life Insurance Co.
Kimberly-Clark of Canada Limited
Kodak Canada Ltd.
Koffler Stores Limited
Labatt Breweries of Canada Limited
London Life Insurance Company
Mack Trucks Canada Limited
Maritime Telegraph & Telephone Company Ltd.
Massey-Ferguson Industries Limited
Metropolitan Life Insurance Company
Mobil Oil Canada Ltd.
Molson Companies Donation Fund
National Trust Company Limited
Noxzema Chemical Company of Canada Limited
Ogilvie Flour Mills Company Limited
Ontario Paper Company Limited
Pfizer Company Limited
Prudential Assurance Company Limited
Rolland Paper Company Limited
Rothmans of Pall Mall Canada Limited
Scott Misener Steamships Limited
Shell Canada Limited
Simpsons-Sears Limited
Steel Company of Canada Limited
Steinberg's Limited
Sun Oil Company Ltd.
Swift Canadian Co. Limited
Toronto Star Limited
Union Carbide Canada Limited
Woodward's
F.W. Woolworth Co. Limited
Zerox of Canada Limited

70

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY